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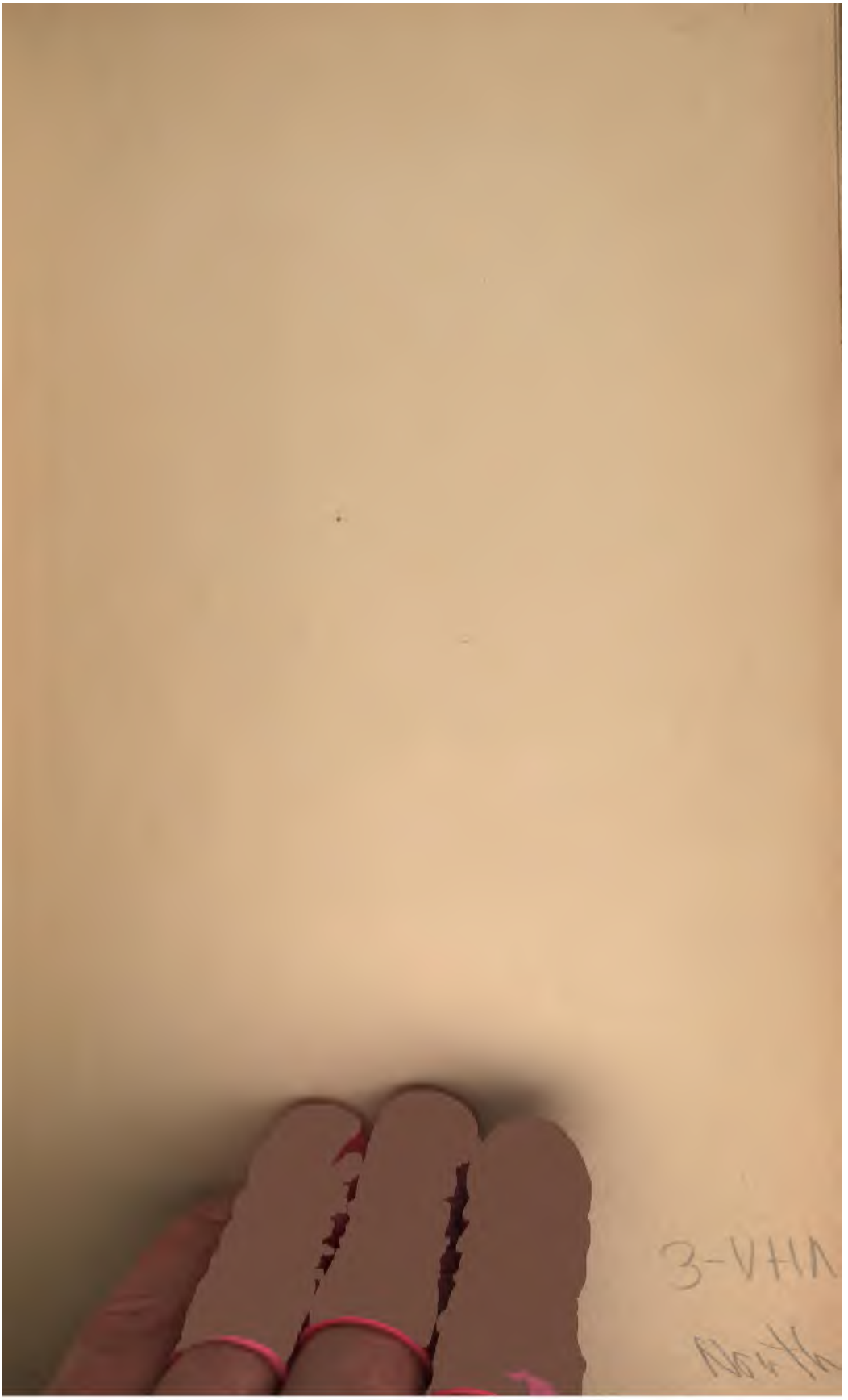
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NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

TRANSACTIONS

VOL. XXXVI.

1886-7.

NEWCASTLE-UPON-TYNE: A. REID, PRINTING COURT BUILDINGS, AKENSIDE HILL.

1887.

'11, 2927, July 11

NEWCASTLE-UPON-TYNE:

ANDREW REID, PRINTING COURT BUILDINGS, AKENSIDE HILL

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Report.

The Council have pleasure in being able to report the continued prosperity of the Institute.

The year 1886-87 has been a most eventful one. In the last report of the Council it will be remembered that mention was made of the Royal Mining, Engineering, and Industrial Exhibition to be held in Newcastle, the inception of which was due to the members of the Institute. It was stated that Mr. Daglish, the then President, had been elected Chairman of the Executive Council and that the scheme had received large promises of support. It is now our pleasing duty to record the successful completion of this Exhibition and the effective way in which members of the Institute have contributed to its success.

The Council cannot refrain from mentioning the able assistance rendered by Mr. G. B. Forster and Mr. Thos. J. Bewick, who have, with their respective Committees, succeeded in giving such perfect representations of Coal and Lead Mines, and their thanks are also due to Mr. May for the great attention he has given to the Haulage Section and the display of contrivances for facilitating the transit of coal, which form some of the most important and interesting features of the Exhibition.

There seems every reason to hope that as it has obtained the approval of the public as a brilliant and interesting display of all that is most worthy of notice in the way of modern inventions and of much that is of historical interest, it will also be a financial success.

Seeing how attractive the Exhibition has proved to be from the day it was opened, it was considered that it would be an opportune occasion to invite the members of all the English and Foreign Mining Institutions, together with the managing bodies of kindred Societies, the City Council, the members of the River Tyne Commission, and others, to a conversazione in the building itself, and to make arrangements to enable them to inspect such works and collieries as were thought most worthy of examination, and the Council have pleasure in stating that through the kindness of the owners, a large number of collieries and engineering and other works have been thrown open to the guests, who have just now completed their visit.

The opinion of the Council has been asked as to the advisability of the City of Newcastle sending a deputation to Manchester to invite the British Association to hold its 1889 meeting in this city, and it has been unanimously decided that it is very desirable that this Association should be induced to pay the contemplated visit.

An important matter for congratulation is that the Council of the Durham College of Science, another valuable institution which owes its inception to this Institute, and especially to the earnest work of one of its oldest members, Mr. E. F. Boyd, in the cause, have commenced to build an edifice worthy of the position the College holds as an educational body. The career of the College has been so far successful; the number of regular matriculated students it has enrolled has been larger than those enrolled by similar educational establishments in their early years; while the number of students who have obtained distinction and have risen to responsible positions in life has been in proportion to the matriculations very large. It is well worthy of consideration whether the funds at the disposal of the Institute can be usefully employed in promoting the future success of this undertaking, which promises to be of great value, especially as regards the education of students intending to follow the profession of Mining Engineering.

The Principal of the College, in conjunction with the Council of the North-East Coast Institution of Engineers and Shipbuilders, has indicated a course of study for the training of young men desiring to enter the profession of marine engineering and shipbuilding, and has submitted a plan of the proposed plant, buildings, and arrangements necessary to give effect to the same. This will involve an expenditure of about £24,000, which, it is hoped, will be supplied by the various interested manufacturers in the district. The College has invited this Institute to co-operate in a similar way as regards the mining profession, and a committee has been formed to confer with the Principal as to the details.

The papers which have been read before the members are of the usually high standard. As might be expected from the importance that is now attached to the presence of dust, with or without gas, in coal workings, a considerable number have treated on safety-lamps with the means of detecting gas, and on laying dust. Mr. Schanschieff's lamp, with a primary fluid battery, and Mr. Swan's lamp, with a secondary battery, were both considered incomplete if not accompanied with some means of detecting the amount of gas present in the mine; and both gentlemen, together with Sir W. T. Lewis and Mr. Maurice, have contributed descriptions of apparatus to be used when electric lights are employed for ascertaining the amounts

of gas present. Mr. Robson has described a very neat apparatus for laying dust in the wagon-ways and workings, and Professor Merivale read an elaborate paper on the transmission of power by steam in mines. Two geological papers of considerable interest have been contributed, one by Professor Lebour on the Coal-Measures in Catalonia, and one by Mr. Halse on the Manganese Ores in Merionethshire. Mr. Walton Brown's paper on some experiments which have been made in France to ascertain the probable connection between movements in the earth's crust and the issues of gas in mines, deserves more than a passing comment. This important subject is at present in the hands of a committee, who have purchased instruments and are endeavouring to form some definite ideas on this subject. Mr. Brown has also contributed a description of a simple instrument for determining the specific gravity of bodies.

Finance Report.

THE Income for the year 1886-87 amounted to £1,754 2s. 4d., being an increase over that for the previous year of £39 3s. 7d. The Expenditure was £1,566 12s. 9d., £57 15s. 10d. less than that of the preceding year. The surplus of income over expenditure was £187 9s. 7d.

The total amount of subscriptions and arrears received was £1,386.

The arrears of unpaid subscriptions, varying from one to four years, are £519 15s., being £22 1s. less than last year.

(Signed) WILLIAM COCHRANE.
G. B. FORSTER.

July 23rd, 1887.

ADVERTISEMENT.

THE Institute is not, as a body, responsible for the facts and opinions advanced in the Papers read, and in the Abstracts of the Conversations which occurred at the Meetings during the Session.

TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND

Dr. *July 20th, 1886,*

July 20, 1886.													£	s.	d.	£	s.	d.
To Balance at Bankers ...	...	...	...	...	...	...							211	15	9			
„ „ in hands of Cashier	...	...	...	...	...								10	6	8			
																222	2	5
July 19, 1887.																		
To Dividend at the rate of 7 % per annum on 134 Shares of £20 each in the Institute and Coal Trade Chambers Company, Ld., for the Half-Year ending Dec. 1886...													93	16	0			
To ditto, ditto, Half-Year ending June, 1887, at 8½ % per annum	...	...	...	...	...	...	...						113	18	0			
													207	14	0			
To Interest on Investments with the River Tyne Commissioners	...	...	...	...	...	...	...						87	0	5			
																294	14	5
To Rent of College Class Rooms	...	...	...	...									48	14	2			
To College of Medicine (acknowledgment)	...	...	...											5	0			
																48	19	2
To Subscriptions for 1886-87, from 354 Original Members ...													743	8	0			
To Do. do. 25 Ordinary do. ...													76	13	0			
To Do. do. 121 Associate do. ...													254	2	0			
To Do. do. 49 Students													51	9	0			
To Do. do. 2 New Ordinary Members													6	6	0			
To Do. do. 12 New Associate do.													25	4	0			
To Do. do. 2 New Students ...													2	2	0			
To 1 Student paid extra as an Associate				...	...	...							1	1	0			
													1,160	5	0			
To Subscribing Collieries, &c.:—																		
Ashington ...	...	...	...								£2	2	0					
Birtley Iron Company ...	...	...									6	6	0					
Haswell ...	...	...	...	...							4	4	0					
Hetton ...	...	...	...	...							10	10	0					
Lambton ...	...	...	...	...							10	10	0					
Londonderry ...	...	...	...								10	10	0					
Marquis of Bute	...	...	...								10	10	0					
North Hetton ...	...	...	...								6	6	0					
Ryhope ...	...	...	...	...							4	4	0					
Seghill ...	...	...	...	...							2	2	0					
South Hetton and Murton		...	...								4	4	0					
Stella ...	...	...	...	...							2	2	0					
Throckley ...	...	...	...								2	2	0					
Victoria Garesfield	...	...	...								2	2	0					
Wearmouth ...	...	...	...								4	4	0					
														81	18	0		
													1,242	3	0			
To Members' Arrears ...	...	...	...								£112	7	0					
To Students' do. ...	...	...	...								23	2	0					
To Arrears considered as Irrecoverable, but since Paid	...	...	...								8	8	0					
														143	17	0		
																1,386	0	0
To Sale of Publications per A. Reid ...		...									£23	5	3					
Less 10 % Commission ...	...	...									2	6	6					
														20	18	9		
To Sale of Publications by the Secretary		...	...	...										3	10	0		
																24	8	9
																£1,976	4	9

INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

to July 19th, 1887. CR.

1887. July 19.	£	s.	d.	£	s.	d.
By Andrew Reid:—						
Publishing Account	386	18	6			
Covers for Parts, Folding and Stitching	27	8	7			
Binding and Sewing Volumes	9	15	10			
Borings and Sections	59	17	0			
Library Catalogue	17	8	0			
Library	28	7	6			
Stationery and Circulars	70	19	10			
Postage	43	13	2			
				644	8	5
By Books for Library, in addition to amount paid A. Reid	31	8	8			
By Printing and Stationery do. do.	1	1	11			
By Abstracts of Foreign Papers	44	15	10			
By Secretary's Incidental Expenses and Postages	58	2	9			
By Sundry Accounts and Payments	41	4	5			
By Travelling Expenses	1	9	3			
By Secretary's Salary	300	0	0			
By Cashier's do.	75	0	0			
By Clerks' Wages	152	15	0			
By Reporter's Salary	12	12	0			
By Rent...	78	2	10			
By Rates and Taxes	17	10	8			
By Fire Insurance	8	14	11			
By Water, Gas, and Coals	7	16	11			
				830	15	2
By Sopwith & Co., Lamp Case for Exhibition	36	5	0			
By Geological Society's Visit, Luncheon	14	9	2			
By British Association Meeting, Delegate's Expenses ...	18	0	0			
By Wailes & Strang, Wood Memorial Hall Window ...	8	5	0			
By Cambridge Scientific Instrument Co., for Seismograph	14	10	0			
				91	9	2
				1,566	12	9
By Balance at Bankers	395	1	10			
By Do. in hands of Cashier	14	10	2			
				409	12	0
				£1,976	4	9

Audited and found correct,

JOHN G. BENSON,

CHARTERED ACCOUNTANT.

Newcastle-upon-Tyne,

5th August, 1887.

DR. THE TREASURER IN ACCOUNT

	£	s.	d.
To 439 Original Members, as per List, 1886-87.			
11 of whom are Life Members.			
428 @ £2 2s.	898	16	0
To 41 Ordinary Members, as per List, 1886-87.			
3 of whom are Life Members.			
38, viz., 35 @ £3 3s. and 3 @ £2 2s.	116	11	0
To 156 Associate Members, as per List, 1886-87.			
7 of whom are Life Members.			
149			
1 replaced.			
150 @ £2 2s.	315	0	0
To 69 Students, as per List, 1886-87, @ £1 1s.	72	9	0
To 1 Student paid extra as an Associate	1	1	0
To 2 New Ordinary Members, @ £3 3s.	6	6	0
To 13 New Associate Members, @ £2 2s.	27	6	0
To 2 New Students, at £1 1s.	2	2	0
To Subscribing Collieries, &c.	81	18	0
	1,521	9	0
To Arrears as per Balance Sheet, 1885-86 ... ... 541 16 0			
Deduct—Irrecoverable 165 18 0			
375 18 0			
Add—Arrears considered irrecoverable since paid ... 8 8 0			
	384	6	0
	£1,905	15	0

WITH SUBSCRIPTIONS, 1886–87. CR.

			PAID. £ s. d.	UNPAID. £ s. d.
By 354	Original Members paid @ £2 2s.		743 8 0	
By 59	Do. unpaid „		.....	123 18 0
By 6	Do. dead „		.....	12 12 0
By 5	Do. resigned „		.....	10 10 0
By 3	Do. gone, no address, @ £2 2s. ...		.....	6 6 0
By 1	Do. struck off „ ...		.....	2 2 0
428				
By 23	Ordinary Members paid @ £3 3s.		72 9 0	.....
By 2	Do. „ @ £2 2s.		4 4 0	.....
By 11	Do. unpaid @ £3 3s.		.....	34 13 0
By 1	Do. „ @ £2 2s.		.....	2 2 0
By 1	Do. struck off @ £3 3s.		.....	3 3 0
38				
By 121	Associate Members paid @ £2 2s.		254 2 0	.....
By 24	Do. unpaid „		.....	50 8 0
By 2	Do. dead „		.....	4 4 0
By 2	Do. resigned „		.....	4 4 0
By 1	Do. struck off „		.....	2 2 0
150				
By 49	Students paid @ £1 1s.		51 9 0	.....
By 17	Do. unpaid „		.....	17 17 0
By 3	Do. gone, no address „		.....	3 3 0
69				
By 1	Student paid extra as an Associate		1 1 0	.....
By 2	New Ordinary Members paid @ £3 3s.		6 6 0	.....
By 12	New Associate Members paid @ £2 2s.... ...		25 4 0	.....
By 1	Do. unpaid „		.....	2 2 0
13				
By 2	New Students paid @ £1 1s.		2 2 0	.....
By Subscribing Collieries paid			81 18 0	.....
			1,242 3 0	279 6 0
By Members' Arrears			112 7 0	215 5 0
By Students' do.			23 2 0	25 4 0
By Arrears considered as irrecoverable			8 8 0	.....
			1,386 0 0	519 15 0
				1,386 0 0
				£1,905 15 0

DR. GENERAL STATEMENT, JULY 19TH, 1887. CR.

Liabilities.	£	s.	d.
None	.....		
Capital	11,647	10	0
	£11,647	10	0

Audited and found correct,
(Share Certificates and Bonds produced.)
JOHN G. BENSON,
CHARTERED ACCOUNTANT.
Newcastle-on-Tyne,
5th August, 1887.

Assets.		£	s.	d.
Balance of Account at Bankers	£395 1 10			
Do. in Cashier's hand	14 10 2			
		409	12	0
134 Shares of £20 each in the Institute and Coal Trade Chambers Company, Limited		2,680	0	0
Invested with the River Tyne Commissioners...		2,000	0	0
Arrears of Subscriptions		519	15	0
Value of 484 Bound Volumes of Transactions, @ 11s. 6d. ...		278	6	0
Value of 4,406 Sewn Copies of Transactions, @ 9s.		1,982	14	0
Value of Sundry Unbound Parts of Transactions		80	0	0
Value of 35 Copies of Mr. T. F. Brown's Map, @ 5s. ...		8	15	0
Value of 381 Copies of General Index, @ 3s.		57	3	0
Value of 764 Copies of Fossil Illustrations, @ 12s. 6d. ...		477	10	0
Value of 855 Copies of Catalogue of Fossils, at 5s.		213	15	0
Value of 316 Copies of Borings and Sinkings, Vol. I., @ 5s.		79	0	0
Value of 329 Copies of Borings and Sinkings, Vol. II., @ 5s.		82	5	0
Value of 352 Copies of Borings and Sinkings, Vol. III., @ 5s.		88	0	0
Value of 1,500 Copies of Borings and Sinkings, Vol. I., in Sheets		300	0	0
Value of Sheets of Borings and Sinkings, Vol. IV., unpublished at date		125	0	0
Value of 263 Copies of Library Catalogue, @ 5s.		65	15	0
Value of Office Furniture and Fittings		450	0	0
Value of Books and Maps in Library		1,750	0	0
		£11,647	10	0

Patrons.

His Grace the DUKE OF NORTHUMBERLAND.

His Grace the DUKE OF CLEVELAND.

The Most Noble the MARQUESS OF LONDONDERRY.

The Right Honourable the EARL OF LONSDALE.

The Right Honourable the EARL OF DURHAM.

The Right Honourable the EARL GREY.

The Right Honourable the EARL OF RAVENSWORTH.

The Right Honourable the EARL OF WHARNCLIFFE.

The Right Reverend the LORD BISHOP OF DURHAM.

The Very Reverend the DEAN AND CHAPTER OF DURHAM.

WENTWORTH B. BEAUMONT, Esq., M.P

Honorary Members.

* Honorary Members during term of office only.

	Elected. Mem.	Hon.
The Right Honourable the EARL OF RAVENSWORTH, Ravensworth Castle, Gateshead-on-Tyne...		1877
* Prof. P. PHILLIPS BEDSON, D.Sc. (Lond.), F.G.S., Durham College of Science, Newcastle-on-Tyne		1885
M. DE BOUREUILLE, Commandeur de la Légion d'Honneur, Conseiller d'état, Inspecteur General des Mines, Paris ...		1853
* Prof. G. S. BRADY, M.D., F.R.S., F.L.S., Durham College of Science, Newcastle-on-Tyne		1875
Dr. BRASSERT, Berghauptmann, Bonn-am-Rhein, Prussia ...		1883
Dr. H. VON DECHEN, Berghauptmann, Bonn-am-Rhein, Prussia...		1853
JOSEPH DICKINSON, Esq., F.G.S., Inspector of Mines, Manchester		1853
THOMAS EVANS, Esq., F.G.S., Inspector of Mines, Pen-y-Bryn, Duffield Road, Derby		1855
* Prof. WILLIAM GARNETT, M.A., D.C.L., Principal of the Durham College of Science, Newcastle-on-Tyne		1884
M. THEOPHILE GUIBAL, School of Mines, Mons, Belgium ...		1870
* HENRY HALL, Esq., Inspector of Mines, Rainhill, Prescott ...		1876
* Prof. A. S. HERSCHEL, M.A., D.C.L., F.R.S., F.R.A.S., Durham College of Science, Newcastle-on-Tyne		1872
The Very Rev. Dr. LAKE, Dean of Durham		1872
* Prof. G. A. LEBOUR, M.A., F.G.S., Durham College of Science, Newcastle-on-Tyne	1873	1879
J. A. LONGRIDGE, Esq., Grêve d'Ayetté, Jersey		1886
* RALPH MOORE, Esq., Inspector of Mines, Glasgow		1866
Sir WARINGTON W. SMYTH, M.A., F.R.S., F.G.S., F.R.G.S., 28, Jermyn Street, London		1869
M. E. VUILLEMIN, Mines d'Aniche, Nord, France		1878
* FRANK N. WARDELL, Esq., F.G.S., Inspector of Mines, Wath-on-Dearne, near Rotherham	1864	1868
* JAMES WILLIS, Esq., Inspector of Mines, 14, Portland Terrace, Newcastle-on-Tyne	1857	1871
THOMAS WYNNE, Esq., F.G.S., Inspector of Mines, Manor House, Gnosall, Stafford		1853

Life Members.

	Elected. Mem.	Life.
C. W. BARTHOLOMEW, Esq., Blakesley Hall, near Towcester ...	1875	1875
THOS. HUGH BELL, Esq., Middlesbro'-on-Tees	1882	1882
DAVID BURNS, Esq., C.E., F.G.S., Clydesdale Bank Buildings, Bank Street, Carlisle	1877	1877
T. E. CANDLER, Esq., F.G.S., Canton Club, Canton, China... ...	1875	1885
E. B. COXE, Esq., Drifton, Jeddo, P.O., Luzerne Co., Penns., U.S. ...	1873	1874
JAMES S. DIXON, Esq., 170, Hope Street, Glasgow	1878	1880
ERNEST HAGUE, Esq., Castle Dyke, Sheffield	1872	1876
G. C. HEWITT, Esq., Coal Pit Heath Colliery, near Bristol ...	1871	1879
JAMES HILTON, Esq., Wigan Coal and Iron Co., Limited, Wigan...	1867	1883
THOS. E. JOBLING, Esq., Croft Villa, Blyth, Northumberland ...	1876	1882
ROBERT KNOWLES, Esq., Arncliffe, Cheetham Hill, Manchester...	1886	1886
HENRY LAPORTE, Esq., M.E., Aciéries de France, Aubin, Aveyron, France	1877	1877
W. MERIVALE, Esq., Kirwee, Manikpur, Bhopal, Central India ...	1881	1884
NATHAN MILLER, Esq.	1878	1878
H. J. MORTON, Esq., 2, Westbourne Villas, South Cliff, Scarborough	1856	1861
RUDOLPH NASSE, Esq., Oberbergrath, Dortmund, Prussia ...	1869	1880
ARTHUR PEASE, Esq., Darlington	1882	1882
EDWARD G. PRIOR, Esq., Victoria, British Columbia	1880	1883
WALTER SAISE, D. Sc. (London), M. Inst. C.E., Manager E.I.R. Collieries, Giridih, Bengal, India	1877	1887
R. CLIFFORD SMITH, Esq., F.G.S., Parkfield, Swinton, Manchester	1874	1874
T. H. WARD, Esq., F.G.S., Assistant Manager, East Indian Railway Collieries, Giridi, Bengal, India	1882	1882

OFFICERS, 1887-88.

President.

SIR LOWTHIAN BELL, Bart., F.R.S., F.C.S., Rounton Grange, Northallerton.

Vice-Presidents.

WM. ARMSTRONG, Esq., F,G.S., Pelaw House, Chester-le-Street.
CUTHBERT BERKLEY, Esq., Marley Hill, Whickham, R.S.O., Co. Durham.
SIR BENJAMIN C. BROWNE, M.I.C.E., 2, Granville Road, Jesmond, Newcastle.
THOMAS DOUGLAS, Esq., Peases' West Collieries, Darlington.
A. L. STEAVENSON, Esq., Durham.
JAMES WILLIS, Esq., 14, Portland Terrace, Newcastle-on-Tyne.

Council.

WM. ARMSTRONG, Jun., Esq., Wingate, County Durham.
J. B. ATKINSON, Esq., Stocksfield-on-Tyne.
T. W. BENSON, Esq., 11, Newgate Street, Newcastle-on-Tyne.
M. WALTON BROWN, Esq., 3, Summerhill Terrace, Newcastle-on-Tyne.
W. H. HEDLEY, Esq., Consett Collieries, Medomsley, Newcastle-on-Tyne.
THOS. HEPPELL, Esq., Leafield House, Birtley, Chester-le-Street.
HENRY LAWRENCE, Esq., Grange Iron Works, Durham.
PROF. G. A. LEBOUR, M.A., F.G.S., Durham College of Science, Newcastle.
PROF. J. H. MERIVALE, M.A., 2, Victoria Villas, Newcastle-on-Tyne.
M. W. PARRINGTON, Esq., Wearmouth Colliery, Sunderland.
THE HON. CHARLES A. PARSONS, Elvaston Hall, Ryton-on-Tyne.
A. M. POTTER, Esq., Shire Moor Colliery, Earsdon, Newcastle-on-Tyne.
R. ROBINSON, Esq., Howlish Hall, near Bishop Auckland.
J. B. SIMPSON, Esq., F.G.S., Hedgefield House, Blaydon-on-Tyne.
J. G. WEEKS, Esq., Bedlington, R.S.O., Northumberland.
W. H. WOOD, Esq., Coxhoe Hall, Coxhoe, County Durham.
W. O. WOOD, Esq., South Hetton, Fence Houses.
THOMAS WRIGHTSON, Esq., Stockton-on-Tees.

Ex-officio (Past Presidents.)

LORD ARMSTRONG, C.B., LL.D., F.R.S., D.C.L., Jesmond, Newcastle.
E. F. BOYD, Esq., F.G.S., Moor House, Leamside, Fence Houses.
JOHN DAGLISH, Esq., Marsden, South Shields.
SIR GEORGE ELLIOT, Bart., M.P., D.C.L., Houghton Hall, Fence Houses.
G. B. FORSTER, Esq., M.A., F.G.S., Lesbury, R.S.O., Northumberland
G. C. GREENWELL, Esq., F.G.S., Elm Tree Lodge, Duffield, Derby.
LINDSAY WOOD, Esq., Southill, Chester-le-Street.

(Retiring Vice-Presidents.)

T. J. BEWICK, Esq., M.I.C.E., F.G.S., Suffolk House, Laurence Pountney Hill, near London, E.C.
WM. COCHRANE, Esq., Grainger Street West, Newcastle.

Secretary and Treasurer.

THEO. WOOD BUNNING, Neville Hall, Newcastle-on-Tyne.

List of Members.

AUGUST, 1887.

Original Members.

Marked * are Life Members.

		ELECTED
1	AITKIN, HENRY, Falkirk, N.B.	Mar. 2, 1865
2	ANDERSON, C. W., Belvedere, Harrogate	Aug. 21, 1852
3	ANDREWS, HUGH, Swarland Hall, Felton, Northumberland	Oct. 5, 1872
4	ARCHER, T., Dunston Engine Works, Gateshead	July 2, 1872
5	ARMSTRONG, LORD, C.B., LL.D., F.R.S., D.C.L., Jesmond, Newcastle-on-Tyne (PAST PRESIDENT, *Member of Council)*	May 3, 1866
6	ARMSTRONG, WM., F.G.S., Pelaw House, Chester-le-Street (VICE-PRESIDENT)	Aug. 21, 1852
7	ARMSTRONG, W., Jun., Wingate, Co. Durham *(Member of Council)*	April 7, 1867
8	ARMSTRONG, W. L., Oaklands Rock, near Bewdley	Mar. 3, 1864
9	ARTHUR, D., M.E., Sherfin House, Baxenden, nr. Accrington, Manchester	Aug. 4, 1877
10	ASHWORTH, JAMES, Stanley Hall, near Derby	Feb. 5, 1876
11	ASQUITH, T. W., Harperley, Lintz Green, Newcastle-on-Tyne ...	Feb. 2, 1867
12	ATKINSON, J. B., Stocksfield-on-Tyne *(Member of Council)*	Mar. 5, 1870
13	ATKINSON, W. N., Shincliffe Hall, Durham	June 6, 1868
14	AUBREY, R. C., Wigan Coal & Iron Co. Ld., Standish, near Wigan ...	Feb. 5, 1870
15	AUSTINE, JOHN, Cadzow Coal Co., Glasgow	Nov. 4, 1876
16	AYNSLEY, WM., Chilton Colliery, Ferry Hill	Mar. 3, 1873
17	BAILES, GEORGE, Murton Colliery, Sunderland	Feb. 3, 1877
18	BAILES, T., 6, Collingwood Terrace, Jesmond Gardens, Newcastle ...	Oct. 7, 1858
19	BAILES, W., Cortonwood Collieries, Wombwell, near Barnsley ...	April 7, 1877
20	BAILEY, SAMUEL, Perry Barr, Birmingham	June 2, 1859
21	BAIN, R. DONALD, Newport, Monmouthshire	Mar. 3, 1873
22	BAINBRIDGE, E., Nunnery Colliery Offices, Sheffield	Dec. 3, 1863
23	BANKS, THOMAS, 60, King Street, Manchester	Aug. 4, 1877
24	BARCLAY, A., Caledonia Foundry, Kilmarnock	Dec. 6, 1866
25	BARTHOLOMEW, C., Castle Hill House, Ealing, London, W.	Aug. 5, 1853
26*	BARTHOLOMEW, C. W., Blakesley Hall, near Towcester	Dec. 4, 1875
27	BATES, MATTHEW, Bews Hill, Blaydon-on-Tyne	Mar. 3, 1873
28	BATES, W. J., Winlaton, Blaydon-on-Tyne	Mar. 3, 1873
29	BATEY, JOHN, Newbury Collieries, Coleford, Bath	Dec. 5, 1868
30	BEANLANDS, A., M.A., North Bailey, Durham	Mar. 7, 1867
31	BELL, SIR LOWTHIAN, Bart., F.R.S., F.C.S., Rounton Grange, Northallerton, (PRESIDENT)	July 6, 1854
32	BELL, JOHN, Messrs. Bell Brothers, Middlesbro'-on-Tees	Oct. 1, 1857
33	BENSON, J. G., Accountant, 12, Grey Street, Newcastle-on-Tyne ..	Nov. 7, 1874
34	BENSON, T. W., 11, Newgate Street, Newcastle *(Member of Council)*	Aug. 2, 1866

ELECTED.

35 BERKLEY, C., Marley Hill, Whickham, R.S.O., Co. Durham (VICE-PRESIDENT) ... ... Aug. 21, 1852

36 BEWICK, T. J., M.I.C.E., F.G.S., Suffolk House, Laurence Pountney Hill, near London (RETIRING VICE-PRESIDENT, *Member of Council)* ... ... April 5, 1860

37 BIGLAND, J., Bedford Lodge, Bishop Auckland ... ... June 4, 1857

38 BIRAM, B., Peaseley Cross Collieries, St. Helen's, Lancashire ... 1856

39 BLACK, W., Hedworth Villa, South Shields ... ... April 2, 1870

40 BOLTON, H. H., Newchurch Collieries, near Manchester ... ... Dec. 5, 1868

41 BOOTH, R. L., Ashington Colliery, near Morpeth 1864

42 BOYD, E. F., Moor House, Leamside, Fence Houses (PAST PRESIDENT, *Member of Council)* ... ... Aug. 21, 1852

43 BOYD, R. F., Moor House, Leamside, Fence Houses ... ... Nov. 6, 1869

44 BOYD, WM., 74, Jesmond Road, Newcastle-on-Tyne ... ... Feb. 2, 1867

45 BRECKON, J. R., 32, Fawcett Street, Sunderland ... ... Sept. 3, 1864

46 BRETTELL, T., Mine Agent, Dudley, Worcestershire ... ... Nov. 3, 1866

47 BROMILOW, WM., Preesgweene, near Chirk, North Wales ... ... Sept. 2, 1876

48 BROWN, JOHN, Priory Place, 155, Bristol Road, Birmingham ... Oct. 5, 1854

49 BROWN, J. N., 56, Union Passage, New Street, Birmingham ... 1861

50 BROWN, THOS. FORSTER Guildhall Chambers, Cardiff 1861

51 BROWNE, SIR BENJAMIN C., M.I.C.E., 2, Granville Road, Jesmond, Newcastle (VICE-PRESIDNET) ... ... Oct. 1, 1870

52 BRYHAM, WILLIAM, Rosebridge Colliery, Wigan ... ... Aug. 1, 1861

53 BRYHAM, W., Jun., Douglas Bank Collieries, Wigan ... ... Aug. 3, 1865

54 BUNNING, THEO. WOOD, Neville Hall, Newcastle-on-Tyne *(Secretary and Treasurer)* 1864

55*BURNS, DAVID, C.E., F.G.S., Clydesdale Bank Bgs., Bank St., Carlisle May 5, 1877

56 BURROWS, J. S., Yew Tree House, Atherton, near Manchester ... Oct. 11, 1873

57 CAMPBELL, W. B., Consulting Engineer, Grey Street, Newcastle ... Oct. 7, 1876

58 CARR, WM. COCHRAN, South Benwell, Newcastle-on-Tyne ... ... Dec. 3, 1857

59 CHAMBERS, A. M., Thorncliffe Iron Works, near Sheffield ... ... Mar. 6, 1869

60 CHEESMAN, I. T., Throckley Colliery, Newcastle-on-Tyne ... ... Feb. 1, 1873

61 CHEESMAN, W. T., Wire Rope Manufacturer, Hartlepool ... ... Feb. 5, 1876

62 CLARENCE, THOMAS, Elswick Colliery, Newcastle-on-Tyne ... ... Dec. 4, 1875

63 CLARK, C. F., Garswood Coal and Iron Co., near Wigan ... ... Aug. 2, 1866

64 CLARK, R. B., Marley Hill, near Gateshead ... ... May 3, 1873

65 CLARK, W., M.E., The Grange, Teversall, near Mansfield ... ... April 7, 1866

66 CLARKE, WILLIAM, Victoria Engine Works, Gateshead ... ... Dec. 7, 1867

67 COCHRANE, B., Aldin Grange, Durham ... ... Dec. 6, 1866

68 COCHRANE, C., Green Royde, Pedmore, near Stourbridge ... ... June 3, 1857

69 COCHRANE, W., St. John's Chambers, Grainger Street West, Newcastle (RETIRING VICE-PRESIDENT, *Member of Council)* 1859

70 COLE, RICHARD, Walker Colliery, near Newcastle-on-Tyne ... . April 5, 1873

71 COLE, ROBERT HEATH, Lord Street, Basford, Stoke-upon-Trent ... Feb. 5, 1876

72 COLLIS, W. B., Swinford House, Stourbridge, Worcestershire ... June 6, 1861

73 COOK, J., Jun., Washington Iron Works, Gateshead ... ... May 8, 1869

ELECTED

74 CORBETT, V. W., Chilton Moor, Fence Houses ... ... Sept. 3, 1870
75 CORBITT, M., Wire Rope Manufacturer, Teams, Gateshead ... ... Dec. 4, 1875
76 COULSON, F., 10, Victoria Terrace, Durham ... ... Aug. 1, 1868
77 COULSON, W., High Coniscliffe, Darlington ... ... Oct. 1, 1852
78 COWEY, JOHN, Wearmouth Colliery, Sunderland ... ... Nov. 2, 1872
79 COX, JOHN H., 10, St. George's Square, Sunderland ... ... Feb. 6, 1875
80*COXE, E. B., Drifton, Jeddo, P. O. Luzerne Co., Penns., U.S. ... Feb. 1, 1873
81 COXON, S. B., 3, Poets' Corner, Westminster, London ... ... June 5, 1856
82 CRAWFORD, T., Littletown Colliery, near Durham ... ... Aug. 21, 1852
83 CRAWFORD, T., 3, Grasmere Street, Gateshead-on-Tyne ... ... Sept. 3, 1864
84 CRAWFORD, T., Jun. Littletown Colliery, near Durham ... ... Aug. 7, 1869
85 CRAWSHAY, E., Gateshead-on-Tyne ... ... Dec. 4, 1869
86 CRAWSHAY, G., Gateshead-on-Tyne ... ... Dec. 4, 1869
87 CRONE, E. W., Killingworth Hall, near Newcastle-on-Tyne ... ... Mar. 5, 1870
88 CRONE, J. R., Tudhoe House, *via* Spennymoor ... ... Feb. 1, 1868
89 CRONE, S. C., Killingworth Hall, Newcastle 1853
90 CROSS, JOHN, 77, King Street, Manchester ... ... June 5, 1869
91 CROUDACE, C. J., Bettisfield Colliery Co., Limited, Bagillt, N. Wales Nov. 2, 1872
92 CROUDACE, JOHN, West House, Haltwhistle ... ... June 7, 1873
93 CROUDACE, THOMAS, Lambton Lodge, New South Wales 1862

94 DAGLISH, JOHN, F.G.S., Marsden, South Shields (PAST PRESIDENT, *Member of Council)* ... ... Aug. 21, 1852
95 DAGLISH, W. S., Solicitor, Newcastle-on-Tyne ... ... July 2, 1872
96 DALE, DAVID, West Lodge, Darlington ... ... Feb. 5, 1870
97 D'ANDRIMONT, T., Liége, Belgium ... ... Sept. 3, 1870
98 DANIEL, W., Steam Plough Works, Leeds ... ... June 4, 1870
99 DARLING, FENWICK, South Durham Colliery, Darlington ... ... Nov. 6, 1875
100 DARLINGTON, JAMES, Black Park Colliery, Ruabon, North Wales ... Nov. 7, 1874
101 DARLINGTON, JOHN, 2, Coleman Street Buildings, Moorgate Street, Great Swan Alley, London ... ... April 1, 1865
102 DAVEY, HENRY, C.E., 3 Princes Street, Westminster, London, S.W. Oct. 11, 1873
103 DEES, R. R., Solicitor, Newcastle-on-Tyne ... ... Oct. 7, 1871
104 DIXON, D. W., Lumpsey Mines, Brotton, Saltburn-by-the-Sea ... Nov. 2, 1872
105 DIXON, NICH., Dudley Colliery, Dudley, Northumberland ... ... Sept. 1, 1877
106 DIXON, R., Wire Rope Manufacturer, Teams, Gateshead ... ... June 5, 1875
107 DODD, B., Bearpark Colliery, near Durham ... ... May 3, 1866
108 DODDS, JOSEPH, M.P., Stockton-on-Tees ... ... Mar. 7, 1874
109 DOUGLAS, C. P., Parliament Street, Consett, Co. Durham ... ... Mar. 6, 1869
110 DOUGLAS, T., Pease's' West Collieries, Darlington (VICE-PRESIDENT)... Aug. 21, 1852
111 DOVE, G., Viewfield, Stanwix, Carlisle ... ... July 2, 1872
112 DOWDESWELL, H., Butterknowle Colliery, *via* Darlington ... ... April 5, 1873
113 DYSON, GEORGE, Middlesbro' ... ... June 2, 1866

114 ELLIOT, SIR GEORGE, Bart., M.P., D.C.L., Houghton Hall, Fence Houses, (PAST PRESIDENT, *Member of Council)* ... ... Aug. 21, 1852
115 ELSDON, ROBERT, 76, Manor Road, Upper New Cross, London ... Nov. 4, 1876

ELECTED.

116 EMBLETON, T. W., The Cedars, Methley, Leeds ... ... Sept. 6, 1855
117 EMBLETON, T. W., Jun., The Cedars, Methley, Leeds ... ... Sept. 2, 1865
118 EMINSON, J. B., Londonderry Offices, Seaham Harbour ... ... Mar. 2, 1872
119 EVERARD, I. B., M.E., 6, Millstone Lane, Leicester ... ... Mar. 6, 1869

120 FARMER, A., Seaton Carew, near West Hartlepool ... ... Mar. 2, 1872
121 FARRAR, JAMES, Old Foundry, Barnsley ... ... July 2. 1872
122 FAVELL, THOMAS M., Etruria Iron Works, near Stoke-on-Trent ... April 5, 1873
123 FENWICK, BARNABAS, 84, Osborne Road. Newcastle-on-Tyne ... Aug. 2, 1866
124 FERENS, ROBINSON, Oswald Hall, near Durham ... ... April 7, 1877
125 FIDLER, E., Platt Lane Colliery, Wigan, Lancashire ... ... Sept. 1, 1866
126 FLETCHER, H., Ladyshore Coll., Little Lever, Bolton, Lancashire ... Aug. 3, 1865
127 FLETCHER, JAS., Manager, Co-operative Collieries, Wallsend, near Newcastle, New South Wales ... ... Sept. 11, 1875
128 FLETCHER, JOHN, Rock House, Ulverstone ... ... July 2, 1872
129 FOGGIN, WM., North Biddick Coll., Washington Station, Co. Durham Mar. 6, 1875
130 FORSTER, G. B., M.A., F.G.S., Lesbury, R.S.O., Northumberland (PAST PRESIDENT, *Member of Council)* ... ... Nov. 5, 1852
131 FORSTER, J. R., Water Company's Office, Newcastle-on-Tyne ... July 2, 1872
132 FORSTER, J. T., Burnhope Colliery, near Lanchester, Co. Durham ... Aug. 1, 1868
133 FORSTER, R., 25, Old Elvet, Durham ... ... Sept. 5, 1868
134 FOSTER, GEORGE, Osmondthorpe Colliery, near Leeds ... ... Mar. 7, 1874
135 FRANCE, FRANCIS, St. Helen's Colliery Co. Ld., St. Helen's, Lancashire Sept. 1, 1877
136 FRANCE, W., Lofthouse Mines, Loftus-in-Cleveland, R.S.O. ... ... April 6, 1867
137 FRANKS, GEO., Victoria Garesfield Colliery, Lintz Green, Newcastle ... Feb. 6, 1875

138 GALLOWAY, T. LINDSAY, M.A., Argyll Colliery, Campbeltown, N.B. Sept. 2, 1876
139 GERRARD, JOHN, Westgate, Wakefield ... ... Mar. 5, 1870
140 GILLETT, F. C., 20, Midland Road, Derby ... ... July 4, 1861
141 GILROY, G., Woodlands, Parbold, near Wigan ... ... Aug. 7, 1856
142 GILROY, S. B., Mining Engineer, Hednesford, Stafford ... ... Sept. 5, 1868
143 GJERS, JOHN, Southfield Villas, Middlesbro' ... ... June 7, 1873
144 GODDARD, F. R., Accountant, Newcastle-on-Tyne ... ... Nov. 7, 1874
145 GORDON, JAMES N., c/o W. Nicolson, 5, Jeffrey's Square, St. Mary Axe, London, E.C. ... ... Nov. 6, 1875
146 GRACE, E. N., Dhadka, Asansol, Bengal, India ... ... Feb. 1, 1868
147 GREAVES, J. O., St. John's, Wakefield ... ... Aug. 7, 1862
148 GREEN, J. T., Mining Engineer, Ty Celyn, Abercarne, Newport, Mon. Dec. 3, 1870
149 GREENER, JOHN, General Manager, Vale Coll., New Glasgow, Pictou, Nova Scotia ... ... Feb. 6, 1875
150 GREENWELL, G. C., Elm Tree Lodge, Duffield, Derby (PAST PRESIDENT, *Member of Council)* ... ... Aug. 21, 1852
151 GREENWELL, G. C., Jun., Poynton, near Stockport ... ... Mar. 6, 1869
152 GREY, C. G., Land Commission, 24, Upper Merrion Street, Dublin ... May 4, 1872
153 GRIEVES, D., Brancepeth Colliery, Willington, County Durham ... Nov. 7, 1874
154 GRIFFITH, N. R., Wrexham 1866
155 GRIMSHAW, E. J., 23, Hardshaw Street, St. Helen's, Lancashire ... Sept. 5, 1868

ELECTED.

156 HAGGIE, D. H., Wearmouth Patent Rope Works, Sunderland ... Mar. 4, 1876
157*HAGUE, ERNEST, Castle Dyke, Sheffield ... ... Mar. 2, 1872
158 HAINES, J. RICHARD, Adderley Green Colliery, near Longton ... Nov. 7, 1874
159 HALES, C., Nerquis Cottage, Nerquis, near Mold, Flintshire 1865
160 HALL, M., Lofthouse Station Collieries, near Wakefield ... ... Sept. 5, 1868
161 HALL, M. S., 8, Victoria Street, Bishop Auckland ... ... Feb. 14, 1874
162 HALL, WM., East Hetton Colliery Office, Coxhoe, Co. Durham ... Dec. 4, 1875
163 HALL, WILLIAM F., Haswell Colliery, Haswell, via Sunderland ... May 13, 1858
164 HANN, EDMUND, Aberaman, Aberdare ... ... Sept. 5, 1868
165 HARBOTTLE, W. H., Orrell Coal and Cannel Co., near Wigan ... Dec. 4, 1875
166 HARGREAVES, WILLIAM, Rothwell Haigh, Leeds ... ... Sept. 5, 1868
167 HARLE, RICHARD, Browney Colliery, Durham ... ... April 7, 1877
168 HARLE, WILLIAM, Pagebank Colliery, near Durham ... ... Oct. 7, 1876
169 HARRISON, R., Eastwood, near Nottingham 1861
170 HARRISON, T. E., C.E., Central Station, Newcastle-on-Tyne ... ... May 6, 1853
171 HARRISON, W. B., Brownhills Collieries, near Walsall ... ... April 6, 1867
172 HAY, J., Jun., Widdrington Colliery, Acklington ... ... Sept. 4, 1869
173 HECKELS, Matthew, F.G.S., Walker Colliery, Newcastle-on-Tyne ... April 11, 1874
174 HEDLEY, J. J., Consett Collieries, Leadgate, County Durham ... April 6, 1872
175 HEDLEY, J. L., Flooker's Brook, Chester ... ... Feb. 5, 1870
176 HEDLEY, W. H., Consett Collieries, Medomsley, Newcastle-on-Tyne *(Member of Council)* 1864
177 HENDERSON, H., Pelton Colliery, Chester-le-Street ... ... Feb. 14, 1874
178 HEPPELL, T., Leafield House, Birtley, Chester-le-Street *(Member of Council)* ... ... Aug. 6, 1863
179 HEPPELL, W., Western Hill, Durham ... ... Mar. 2, 1872
180 HERDMAN, J., Park Crescent, Bridgend, Glamorganshire ... ... Oct. 4, 1860
181 HESLOP, C., Lingdale Mines, *via* Skelton, R.S.O., Yorks. ... ... Feb. 1, 1868
182 HESLOP, GRAINGER, Whitwell Coal Company, Sunderland ... ... Oct. 5, 1872
183 HESLOP, J., Cavendish Hill, Sherwood, Nottingham ... ... Feb. 6, 1864
184 HETHERINGTON, D., Coxlodge Colliery, Newcastle-on-Tyne 1859
185*HEWITT, G. C., Coal Pit Heath Colliery, near Bristol ... ... June 3, 1871
186 HEWLETT, A., Haseley Manor, Warwick ... ... Mar. 7, 1861
187 HIGSON, JACOB 1861
188*HILTON, J., Wigan Coal and Iron Co., Limited, Wigan ... ... Dec. 7, 1867
189 HILTON, T. W., Wigan Coal and Iron Co., Limited, Wigan ... ... Aug. 3, 1865
190 HODGSON, J. W. ... ... Feb. 5, 1870
191 HOLLIDAY, MARTIN F., Langley Grove, Durham ... ... May 1, 1875
192 HOLMES, C., Grange Hill, near Bishop Auckland ... ... April 11, 1874
193 HOMER, CHARLES J., Mining Engineer, Stoke-on-Trent ... ... Aug. 3, 1865
194 HOOD, A., 6, Bute Crescent, Cardiff ... ... April 18, 1861
195 HOPE, GEORGE, Success House, Fence Houses ... ... Feb. 3, 1877
196 HORNSBY, H., Rodridge House, Wingate, R.S.O., Co. Durham ... Aug. 1, 1874
197 HORSLEY, W., Whitehill Point, Percy Main, Newcastle-on-Tyne ... Mar. 5, 1857
198 HOSKOLD, H. D., C. and M.E., F.R.G.S., F.G.S., M. Soc. A., &c. ... April 1, 1871
199 HOWARD, W. F., 13, Cavendish Street, Chesterfield ... ... Aug. 1, 1861
200 HUMBLE, JOHN, West Pelton, Chester-le-Street ... ... Mar. 4, 1871

ELECTED.

201 HUMBLE, JOS., Staveley Works, near Chesterfield ... ... June 2, 1866
202 HUNTER, J., Waratah Coal Co., Charlestown, N.S. Wales, Australia... Mar. 6, 1869
203 HURST, T. G., F.G.S., Osborne Road, Newcastle-on-Tyne ... ... Aug. 21, 1852

204 JACKSON, C. G., Chamber Colliery Co., Limited, Hollinwood ... ... June 4, 1870
205 JACKSON, W. G., Loscoe Grange, Normanton, Yorkshire ... ... June 7, 1873
206 JARRATT, J., Houghton Main Colliery, near Barnsley ... ... Nov. 2, 1867
207 JEFFCOCK, T. W., 18, Bank Street, Sheffield ... ... Sept. 4, 1869
208 JENKINS, W., M.E., Ocean Collieries, Treorky, Glamorgan ... ... Dec. 6, 1862
209 JENKINS, WM., Consett Iron Works, Consett, Durham ... ... May 2, 1874
210 JOHNSON, J., Carlton Main Colliery, Barnsley ... ... Mar. 7, 1874
211 JOHNSON, R. S., Sherburn Hall, Durham ... ... Aug. 21, 1852
212 JOICEY, J. G., Forth Banks West Factory, Newcastle-on-Tyne ... April 10, 1869
213 JOICEY, W. J., Urpeth Lodge, Chester-le-Street ... ... Mar. 6, 1869

214 KENDALL, JOHN D., Roper Street, Whitehaven ... ... Oct. 3, 1874
215 KIMPTON, J. G., 40, St. Mary's Gate, Derby ... ... Oct. 5, 1872
216 KIRKBY, J. W., Ashgrove, Windygates, Fife ... ... Feb. 1, 1873
217 KNOWLES, A., Swinton Old Hall, Manchester ... ... Dec. 5, 1856
218 KNOWLES, JOHN, Westwood, Pendlebury, Manchester ... ... Dec. 5, 1856

219 LAMB, R., Bowthorn Colliery, Cleator Moor, near Whitehaven ... Sept. 2, 1865
220 LAMB, R. O., The Lawn, Ryton-on-Tyne ... ... Aug. 2, 1866
221 LAMB, RICHARD W., 29, Great Cumberland Place, London, W. ... Nov. 2, 1872
222 LANCASTER, JOHN, Bilton Grange, Rugby ... ... Mar. 2, 1865
223 LANDALE, A., Echo Bank, Inverkeithing, Fife ... ... Dec. 2, 1858
224* LAPORTE, HENRY, M.E., Aciéries de France, Aubin, Aveyron, France May 5, 1877
225 LAVERICK, ROBT., West Rainton, Fence Houses ... ... Sept. 2, 1876
226 LAWRENCE, HENRY, Grange Iron Works, Durham *(Mem. of Council)* Aug. 1, 1868
227 LAWS, H., Grainger Street W., Newcastle-on-Tyne ... ... Feb. 6, 1869
228 LEBOUR, G. A., M.A., F.G.S., Durham College of Science, Newcastle, *(Member of Council)* ... ... Feb. 1, 1873
229 LEE, GEORGE, 18, Newcomen Street, Coatham, Redcar ... ... June 4, 1870
230 LESLIE, ANDREW, Coxlodge Hall, Gosforth, Newcastle-on-Tyne ... Sept. 7, 1867
231 LEVER, ELLIS, Bowdon, Cheshire 1861
232 LEWIS, SIR WILLIAM THOMAS, Mardy, Aberdare 1864
233 LIDDELL, G. H., Somerset House, Whitehaven ... ... Sept. 4, 1869
234 LINSLEY, R., Cramlington Colliery, Northumberland ... ... July 2, 1872
235 LINSLEY, S. W., Whitburn Colliery, South Shields ... ... Sept. 4, 1869
236 LISHMAN, T., Jun., Hetton Colliery, Fence Houses ... ... Nov. 5, 1870
237 LISHMAN, WM., Witton-le-Wear... 1857
238 LISHMAN, WM., Bunker Hill, Fence Houses ... ... Mar. 7, 1861
239 LIVESEY, C., Bradford Colliery, near Manchester ... ... Aug. 3, 1865
240 LIVESEY, T., Bradford Colliery, near Manchester ... ... Nov. 7, 1874
241 LLEWELYN, L., Abersychan House, Abersychan ... ... May 4, 1872
242 LOGAN, WILLIAM, Langley Park Colliery, Durham ... ... Sept. 7, 1867
243 LONGBOTHAM, J., Barrow Collieries, Barnsley, Yorkshire ... ... May 2, 1868

ELECTED.

244 LUPTON, A., F.G.S., 6, De Grey Road, Leeds ... ... Nov. 6, 1869

245 MADDISON, HENRY, The Lindens, Darlington ... ... Nov. 6, 1875
246 MALING, C. T., Ford Pottery, Newcastle-on-Tyne ... ... Oct. 5, 1872
247 MAMMATT, J. E., C.E., St. Andrew's Chambers, Leeds 1864
248 MARLEY, JOHN, Thornfield, Darlington ... ... Aug. 21, 1852
249 MARLEY, J. W., Marley, Pinching, & Marley, 41, Threadneedle St. London Aug. 1, 1868
250 MARSHALL, F. C., Messrs. R. & W. Hawthorn, St. Peters, Newcastle. Aug. 2, 1866
251 MARSTON, W. B., Leeswood Vale Oil Works, Mold ... ... Oct. 3, 1868
252 MARTEN, E. B., C.E., Pedmore, near Stourbridge ... ... July 2, 1872
253 MATTHEWS, R. F., Ridley Hall, Bardon Mill, Carlisle ... ... Mar. 5, 1857
254 MAUGHAN, J. A., Nerbudda Coal & Iron Co. Ld., Garrawarra, C.P., India Nov. 7, 1863
255 MAY, GEO., Harton Colliery Offices, near South Shields ... ... Mar. 6, 1862
256 MCCREATH, J., 95, Bath Street, Glasgow ... ... Mar. 5, 1870
257 MCCULLOCH, DAVID, Beech Grove, Kilmarnock, N.B. ... ... Dec. 4, 1875
258 MCMURTRIE, J., Radstock Colliery, Bath ... ... Nov. 7, 1863
259 MERIVALE, PROF. J. H., M.A., 2, Victoria Villas, Newcastle-on-Tyne
(Member of Council) ... ... May 5, 1877
260 MILLER, ROBERT, Silkstone and Worsbro' Park Collieries, Barnsley... Mar. 2, 1865
261 MILLS, M. H., Kirklye Hall, Alfreton ... ... Feb. 4, 1871
262 MITCHELL, CHAS., Jesmond, Newcastle-on-Tyne ... ... April 11, 1874
263 MITCHELL, JOSEPH, Mining Offices, Eldon Street, Barnsley ... ... Feb. 14, 1874
264 MITCHINSON, R., Jun., Pontop Coll., Lintz Green Station, Co. Durham Feb. 4, 1865
265 MONKHOUSE, JOS., Gilcrux, Cockermouth ... ... June 4, 1863
266 MOOR, T., Cambois Colliery, Blyth ... ... Oct. 3, 1868
267 MOOR, WM., Jun., Hetton Colliery, Fence Houses ... ... July 2, 1872
268 MOORE, R. W., Colliery Office, Whitehaven ... ... Nov. 5, 1870
269 MORRIS, W., Waldridge Colliery, Chester-le-Street 1858
270* MORTON, H. J., 2, Westbourne Villas, South Cliff, Scarborough ... Dec. 5, 1856
271 MORTON, H. T., Lambton, Fence Houses ... ... Aug. 21, 1852
272 MUNDLE, ARTHUR, St. Nicholas' Chambers, Newcastle-on-Tyne ... June 5, 1875
273 MUNDLE, W., Redesdale Mines, Bellingham ... ... Aug. 2, 1873

274* NASSE, RUDOLPH, Oberbergrath, Dortmund, Prussia 1869
275 NEVIN, JOHN, Dunbottle House, Mirfield, Normanton ... ... May 2, 1868
276 NEWALL, R. S., Ferndene, Gateshead-on-Tyne ... ... May 2, 1863
277 NICHOLSON, E., Jun., Beamish Colliery, Chester-le-Street ... ... Aug. 7, 1869
278 NICHOLSON, MARSHALL, Middleton Hall, Leeds ... ... Nov. 7, 1863
279 NOBLE, CAPTAIN, C.B., F.R.S., F.R.A.S., F.C.S., Jesmond, Newcastle-on-Tyne ... ... Feb. 3, 1866
280 NORTH, F. W., F.G.S., Rowley Hall Colliery, Dudley, Staffordshire ... Oct. 6, 1864

281 OGDEN, JOHN M., Solicitor, Sunniside, Sunderland ... ... Mar. 5, 1857
282 OGILVIE, A. GRAEME, 8, Grove End Road, St. John's Wood, London Mar. 3, 1877
283 OLIVER, ROBERT, Charlaw Colliery, near Durham .. .. Nov. 6, 1875

284 PALMER, A. S., Usworth Hall, Washington Station, Co. Durham ... July 2, 1872
285 PALMER, SIR CHARLES MARK, Bart., M.P., Quay, Newcastle-on-Tyne Nov. 5, 1852

		ELECTED.
286	PAMELY, C., Springfield, Berw Road, Pontypridd, South Wales	Sept. 5, 1868
287	PANTON, F. S., Silksworth Colliery, Sunderland	Oct. 5, 1867
288	PARRINGTON, M. W., Wearmouth Coll., Sunderland *(Mem. of Council)*	Dec. 1, 1864
289	PARTON, T., F.G.S., Hill Top, West Bromwich	Oct. 2, 1869
290	PEACE, M. W., Wigan, Lancashire	July 2, 1872
291	PEARCE, F. H., Bowling Iron Works, Bradford	Oct. 1, 1857
292	PEASE, Sir J. W., Bart., M.P., Hutton Hall, Guisbro', Yorkshire	Mar. 5, 1857
293	PEEL, JOHN, Wharncliffe Silkstone Collieries, near Barnsley	Nov. 1, 1860
294	PEEL, JOHN, Leasingthorne Colliery, Bishop Auckland	Mar. 3, 1877
295	PEILE, WILLIAM, Cartgate, Hensingham, Whitehaven	Oct. 1, 1863
296	PICKUP, P. W., Rishton, near Blackburn	Feb. 6, 1875
297	PINCHING, ARCHD. E., 41, Threadneedle Street, London	May 5, 1877
298	POTTER, ADDISON, C.B., Heaton Hall, Newcastle-on-Tyne	Mar. 6, 1869
299	POTTER, A. M., Shire Moor Coll., Earsdon, Newcastle *(Mem. of Council)*	Feb. 3, 1872
300	POTTER, C. J., Heaton Hall, Newcastle-on-Tyne	Oct. 3, 1874
301	PRICE, JOHN, 6, Osborne Villas, Jesmond, Newcastle-on-Tyne	Mar. 3, 1877
302	PRICE, J. R., Standish, near Wigan	Aug. 7, 1869
303	PRIESTMAN, JONATHAN, Coal Owner, Newcastle-on-Tyne	Sept. 2, 1871
304	PRINGLE, EDWARD, Choppington Colliery, Northumberland	Aug. 4, 1877
305	RAMSAY, J. A., Middleton St. George, R.S.O., Co. Durham	Mar. 6, 1869
306	RAMSAY, WM., Tursdale Colliery, County Durham	Sept. 11, 1875
307	REED, ROBERT, Felling Colliery, Gateshead	Dec. 3, 1863
308	REES, DANIEL, Glandare, Aberdare	1862
309	REID, ANDREW, Newcastle-on-Tyne	April 2, 1870
310	RICHARDSON, H., Backworth Colliery, Newcastle-on-Tyne	Mar. 2, 1865
311	RICHARDSON, J. W., Iron Shipbuilder, Newcastle-on-Tyne	Sept. 3, 1870
312	RIDLEY, G., Tyne Chambers, 38, Side, Newcastle-on-Tyne	Feb. 4, 1865
313	RIDLEY, J. H., Messrs. R. & W. Hawthorn, Newcastle-on-Tyne	April 6, 1872
314	RIDYARD, J., Bridgewater Offices, Walkden, nr. Bolton-le-Moors, Lan.	Nov. 7, 1874
315	RITSON, U. A., 6, Queen Street, Newcastle-on-Tyne	Oct. 7, 1871
316	RITSON, W. A., Agnes Road, Northampton	April 2, 1870
317	ROBERTSON, W., M.E., 123, St. Vincent Street, Glasgow	Mar. 5, 1870
318	ROBINSON, G. C., Brereton and Hayes Colls., Rugeley, Staffordshire	Nov. 5, 1870
319	ROBINSON, R., Howlish Hall, near Bishop Auckland *(Mem. of Council)*	Feb. 1, 1868
320	ROBSON, J. S., Butterknowle Colliery, *via* Darlington	1853
321	ROBSON, THOMAS, Lumley Colliery, Fence Houses	Oct. 4, 1860
322	ROGERSON, John, Croxdale Hall, Durham	Mar. 6, 1869
323	ROSCAMP, J., Shilbottle Colliery, Lesbury, R.S.O., Northumberland	Feb. 2, 1867
324	ROSS, J. A. G., Consulting Engineer, 13, Belgrave Terrace, Newcastle	July 2, 1872
325	ROSSER, W., Mineral Surveyor, Llanelly, Carmarthenshire	1856
326	ROTHWELL, R. P., 27, Park Place, New York, U.S.	Mar. 5, 1870
327	ROUTLEDGE, Jos., Ryhope Colliery, Sunderland	Sept. 11, 1875
328	ROUTLEDGE, WM., S. and L.C. and R. Co., Reserve Colliery, Sydney, Cape Breton	Aug. 6, 1857
329	RUTHERFORD, J., Halifax Coal Co., Ld., Albion Mines, Nova Scotia	1852

ELECTED.

330 RUTHERFORD, W., So. Derwent Colliery, Annfield Plain, Lintz Green Oct. 3, 1874
331 RYDER, W. J. H., Forth Street Brass Works, Newcastle-on-Tyne ... Nov. 4, 1876

332 SAINT, GEORGE, Vauxhall Collieries, Ruabon, North Wales ... ... April 11, 1874
333 SCARTH, W. T., Raby Castle, Staindrop, Darlington ... ... April 4, 1868
334 SCOTT, ANDREW, Broomhill Colliery, Acklington ... ... Dec. 7, 1867
335 SCOTT, C. F., Medomsley, Lintz Green, Newcastle-on-Tyne ... ... April 11, 1874
336 SCOULAR, G., Cleator Moor, *via* Carnforth ... ... July 2, 1872
337 SHAW, W., Cast Steel Foundry Co., Ld., Middlesbro' ... ... June 3, 1871
338 SHIEL, JOHN, Framwellgate Colliery, County Durham ... ... May 6, 1871
339 SHONE, ISAAC, 4, Westminster Chambers, Victoria Street, London, S.W. 1858
340 SHUTE, C. A., Westoe, South Shields ... ... April 11, 1874
341 SIMPSON, J., Heworth Colliery, near Gateshead-on-Tyne ... ... Dec. 6, 1866
342 SIMPSON, J. B., F.G.S., Hedgefield House, Blaydon-on-Tyne *(Member of Council)* ... ... Oct. 4, 1860
343 SIMPSON, R., Moor House, Ryton-on-Tyne ... ... Aug. 21, 1852
344 SIMPSON, ROBT., Drummond Coll., Westville, Pictou, Nova Scotia ... Dec. 4, 1875
345 SLINN, T., 2, Choppington Street, Westmorland Road, Newcastle ... July 2, 1872
346 SMITH, G. F., Grovehurst, Tunbridge Wells ... ... Aug. 5, 1853
347*SMITH, R. CLIFFORD, F.G.S., Parkfield, Swinton, Manchester ... Dec. 5, 1874
348 SMITH, T. E., Phœnix Foundry, Newgate Street, Newcastle-on-Tyne Dec. 5, 1874
349 SOPWITH, A., Cannock Chase Collieries, near Walsall ... ... Aug. 1, 1868
350 SOPWITH, THOS., 6, Great George St., Westminster, London, S.W. ... Mar. 3, 1877
351 SOUTHERN, R., Burleigh House, The Parade, Tredegarville, Cardiff ... Aug. 3, 1865
352 SOUTHWORTH, THOS., Hindley Green Collieries, near Wigan ... ... May 2, 1874
353 SPENCER, JOHN, Westgate Road, Newcastle-on-Tyne ... ... Sept. 4, 1869
354 SPENCER, M., Newburn, near Newcastle-on-Tyne ... ... Sept. 4, 1869
355 SPENCER, T., Ryton, Newcastle-on-Tyne ... ... Dec. 6, 1866
356 SPENCER, W., Southfields, Leicester ... ... Aug. 21, 1852
357 STEAVENSON, A. L., Durham (VICE-PRESIDENT) ... ... Dec. 6, 1855
358 STEPHENSON, G. R., 9 Victoria Chambers, Westminster, London, S.W. Oct. 4, 1860
359 STEVENSON, R. ... ... Feb. 5, 1876
360 STOBART, W., Pepper Arden, Northallerton ... ... July 2, 1872
361 STOREY, THOS. E., Clough Hall Iron Works, Kidsgrove, Staffordshire Feb. 5, 1876
362 STRAKER, J. H., Stagshaw House, Corbridge-on-Tyne ... ... Oct. 3, 1874
363 STRATTON, T. H. M., Tredegar, South Wales ... ... Dec. 3, 1870
364 SWALLOW, J., Bushblades House, Lintz Green, Newcastle-on-Tyne ... May 2, 1874
365 SWALLOW, R. T., Springwell, Gateshead-on-Tyne 1862
366 SWAN, H. F., Shipbuilder, Newcastle-on-Tyne ... ... Sept. 2, 1871
367 SWAN, J. G., Upsall Hall, near Middlesbro' ... ... Sept. 2, 1871
368 SWANN, C. G., Sec., General Mining Asso. Ld., Blomfield House, London Wall, and New Broad Street., London, E.C. ... ... Aug. 7, 1875

369 TATE, SIMON, Trimdon Grange Colliery, Co. Durham ... ... Sept. 11, 1875
370 TAYLOR, HUGH, King Street, Quay, Newcastle-on-Tyne ... ... Sept. 5, 1856
371 TAYLOR, T., King Street, Quay, Newcastle-on-Tyne ... ... July 2, 1872
372 TAYLOR-SMITH, THOMAS, Greencroft Park, Durham ... ... Aug. 2, 1866

ELECTED

373 THOMPSON, R., Jun., 19, The Crescent, Gateshead ... ... Sept. 7, 1867
374 THOMSON, JOHN, Eston Mines, by Middlesbro' ... ... April 7, 1877
375 THOMSON, JOS. F., Manvers Main Colliery, Rotherham ... ... Feb. 6, 1875
376 TINN, J., C.E., Ashton Iron Rolling Mills, Bedminster, Bristol ... Sept. 7, 1867
377 TYSON, WM. JOHN, Waterloo Terrace, Whitehaven ... ... Mar. 3, 1877
378 TYZACK, D., c/o Mr. Donnison, 71, Westgate Road, Newcastle-on-Tyne Feb. 14, 1874
379 TYZACK, WILFRED, So. Medomsley Coll., Lintz Green, Newcastle ... Oct. 7, 1876

380 VIVIAN, JOHN, Diamond Boring Company, Whitehaven ... ... Mar. 3, 1877

381 WADHAM, E., C. and M.E., Millwood, Dalton-in-Furness ... ... Dec. 7, 1867
382 WALKER, J. S., Pagefield Iron Works, Wigan, Lancashire ... ... Dec. 4, 1869
383 WALKER, W., Hawthorns, Saltburn-by-the-Sea ... ... Mar. 5, 1870
384 WALLACE, HENRY, Trench Hall, Gateshead ... ... Nov. 2, 1872
385 WARD, H., Rodbaston Hall, near Penkridge, Stafford... ... ... Mar. 6, 1862
386 WARDALE, JOHN D., Redheugh Engine Works, Gateshead ... ... May 1, 1875
387 WARDELL, S. C., Doe Hill House, Alfreton ... ... April 1, 1865
388 WATSON, M., Curzon Street, Maryport ... ... Mar. 7, 1868
389 WEEKS, J. G., Bedlington, R.S.O., Northumberland *(Mem. of Council)* Feb. 4, 1865
390 WESTMACOTT, P. G. B., Elswick Iron Works, Newcastle ... ... June 2, 1866
391 WHITE, H., South Hetton Colliery, Fence Houses 1866
392 WHITE, J. F., M.E., Wakefield ... ... July 2, 1872
393 WHITE, J. W. H., Woodlesford, near Leeds ... ... Sept. 2, 1876
394 WHITEHEAD, JAMES, Brindle Lodge, near Preston, Lancashire ... Dec. 4, 1875
395 WHITELAW, JOHN, 118, George Street, Edinburgh ... ... Feb. 5, 1870
396 WHITTEM, THOS. S., Wyken Colliery, near Coventry ... ... Dec. 5, 1874
397 WIDDAS, C., North Bitchburn Colliery, Howden, Darlington... ... Dec. 5, 1868
398 WIGHT, W. H., Cowpen Colliery, Blyth... ... ... Feb. 3, 1877
399 WILD, J. G., Hedley Hope Collieries, Tow Law, by Darlington ... Oct. 5, 1867
400 WILLIAMSON, JOHN, Cannock &c., Collieries, Hednesford ... ... Nov. 2, 1872
401 WILLIS, J., 14, Portland Terrace, Newcastle (VICE-PRESIDENT) ... Mar. 5, 1857
402 WILSON, J. B., Wingfield Iron Works and Colliery, Alfreton... ... Nov. 5, 1852
403 WILSON, ROBERT, Flimby Colliery, Maryport ... ... Aug. 1, 1874
404 WILSON, W. B., Thornley House, Trimdon Grange ... ... Feb. 6, 1869
405 WINTER, T. B., Grey Street, Newcastle-on-Tyne ... ... Oct. 7, 1871
406 WOOD, C. L., Freeland, Forgandenny, Perthshire 1853
407 WOOD, LINDSAY, The Hermitage, Chester-le-Street (PAST PRESIDENT, *Member of Council)*... ... ... Oct. 1, 1857
408 WOOD, THOMAS, Rainton House, Fence Houses ... ... Sept. 3, 1870
409 WOOD, W. H., Coxhoe Hall, Coxhoe, Co. Durham *(Member of Council)* 1856
410 WOOD, W. O., South Hetton, Sunderland *(Member of Council)* ... Nov. 7, 1863
411 WOOLCOCK, HENRY, St. Bees, Cumberland ... ... Mar. 3, 1873
412 WRIGHTSON, T., Stockton-on-Tees *(Member of Council)* ... ... Sept. 13, 1873

Ordinary Members.

Marked * are Life Members.

		ELECTED.
1	ACKROYD, WM., Morley Main Collieries, Morley, nr. Leeds	Feb. 7, 1880
2	BARRETT, C. R., New Seaham, Sunderland	Nov. 7, 1874
3	BELL, C. E., Park House, Durham	Dec. 3, 1870
4	BINNS, G. J., Government Inspector of Mines, Dunedin, New Zealand	Aug. 7, 1886
5	BROJA, RICHARD, Kœniglicher, Oberbergrath, 35, Friédrich Strasse, Halle, a/s.	Nov. 6, 1880
6	CHARLTON, HENRY, Hawks, Crawshay & Sons, Gateshead-on-Tyne	Dec. 9, 1882
7	CROSS, W. ASSHETON, Messrs. R. & W. Hawthorn, Newcastle-on-Tyne	April 12, 1884
8	DACRES, THOMAS, Dearham Colliery, *via* Carlisle	May 4, 1878
9	DAVIES, JOHN, Hartley House, Coundon, Bishop Auckland	April 10, 1886
10	DEES, J. GIBSON, Floraville, Whitehaven	Oct. 13, 1883
11*	DIXON, JAMES S., 170, Hope Street, Glasgow	Aug. 3, 1878
12	ELLIS, W. R., F.G.S., Wigan	June 1, 1878
13	FORREST, B. J., Engineer in Charge, Colonia Ocampo, Gran Chaco, Argentine Republic	April 12, 1884
14	FORREST, J. C., Witley Coal Co., Limited, Halesowen, Birmingham...	April 12, 1884
15	GALLOWAY, WM., Mining Engineer, Cardiff	April 23, 1887
16	GEDDES, GEORGE H., 142 Princes Street, Edinburgh	Oct. 1, 1881
17	GILCHRIST, THOMAS, Eltringham, Prudhoe-on-Tyne	May 4, 1878
18	GOUDIE, J. H., Ironwood, by Watersmeet, Michigan, U.S.A. ...	Sept. 7, 1878
19	JOHNSON, H., Jun., Mining Offices, Trindle Road, Dudley, So. Staff.	Feb. 10, 1883
20	JOHNSON, WILLIAM, The Willows, Benton, near Newcastle-on-Tyne	Dec. 9, 1882
21	KELLETT, WILLIAM, Wigan	June 1, 1878
22	KNOWLES, I., Wigan	Oct. 13, 1883
23*	KNOWLES, ROBERT, Arncliffe, Cheetham Hill, Manchester	April 10, 1886
24	LANCASTER, JOHN, Auchinheath, Southfield and Fence Collieries, Lesmahagow	Sept. 7, 1878
25	LAWS, W. G., Town Hall, Newcastle-on-Tyne	Oct. 2, 1880
26	LEACH, C. C., Swan and Leach, Limited, 141, Briggate, Leeds ...	Mar. 7, 1874
27	LLEWELLIN, DAVID MORGAN, F.G.S., Glanwern Offices, Pontypool ...	May 14, 1881
28	MARTIN, TOM PATTINSON, Allhallows Colliery, Mealsgate, Carlisle ...	Feb. 15, 1879
29	OLDHAM, G. H., Barrett Berhm, De Haap Goldfields, Transvaal, South Africa	Aug. 5, 1882

ELECTED

30 Potts, Jos., Jun., North Cliff, Roker, Sunderland ... ... Dec. 6, 1879
31*Prior, Edward G., Victoria, British Columbia... ... ... Feb. 7, 1880

32 Rhodes, C. E., Carr House, Rotherham ... ... Aug. 4, 1883
33 Rogers, William, 30, King Street, Wigan ... ... Nov. 2, 1878
34 Russell, Robert, Coltness Iron Works, Newmains, N.B. ... ... Aug. 3, 1878
35 Selby, Atherton, Leigh, near Manchester ... ... Oct. 13, 1883
36 Spencer, John W., Newburn, near Newcastle-on-Tyne ... ... May 4, 1878
37 Stevens, James, M.E., Kaiping Mines, c/o H.B.M.'s Consulate, Tientsin, North China ... ... Feb. 14, 1885

38 Topping, Walter, Messrs. Cross, Tetley, & Co., Bamfurlong, nr. Wigan Mar. 2, 1878

39 Varty, Thomas, Skelton Park Mines, Skelton, R.S.O., Yorks ... Feb. 12, 1887

40 Walker, Sydney Ferris, 196, Severn Road, Canton, Cardiff ... Dec. 9, 1882
41 Walker, William Edward, Lowther Street, Whitehaven ... ... Nov. 19, 1881
42 Winstanley, Robt., M.E., 28, Deansgate, Manchester ... ... Sept. 7, 1878

Associate Members.

Marked * are Life Members

1 Agniel, S., Mines de Vicoigne (Nord), Nœux (P. de C.), France ... April 23, 1887
2 Allan, John, Minas de Rio Zinto, Huelva, Spain ... ... Feb. 10, 1883
3 Allison, J. J. C., Hedley Hill Colliery, Waterhouses, Durham ... Feb. 13, 1886
4 Armstrong, Henry, Pelaw House, Chester-le-Street ... ... April 14, 1883
5 Armstrong, J. H., St. Nicholas' Chambers, Newcastle-on-Tyne ... Aug. 1, 1885
6 Armstrong, T. J., Hawthorn Terrace, Newcastle-on-Tyne ... ... Feb. 10, 1883
7 Arnold, Thos., Mineral Surveyor, Castle Hill, Greenfields, Llanelly Oct. 2, 1880
8 Atkinson, A. A., Westerton, Bishop Auckland ... ... Aug. 3, 1878
9 Atkinson, Fred., Maryport ... ... Feb. 14, 1874
10 Audus, T., Mineral Traffic Manager, N.E. Railway, Newcastle-on-Tyne Aug. 7, 1880
11 Ayton, E. F., El Boté Mining Negociation, Zacatecas, Mexico ... Feb. 5, 1876
12 Ayton, Henry, Cowpen Colliery, Blyth, Northumberland ... ... Mar. 6, 1875

13 Bailes, E. T., Wingate, Ferryhill ... ... June 7, 1879
14 Ball, Alfred F., 14, Landsdowne Terrace, Gosforth ... ... Dec. 11, 1886
15 Bell, Geo. Fred., 2, Belmont Crescent, Hillhead, Glasgow ... ... Sept. 6, 1879
16*Bell, Thomas Hugh, Middlesbro'-on-Tees ... ... Dec. 11, 1882
17 Bennett, Alfred H., Dean Lane Collieries, Bedminster, Bristol ... April 10, 1886
18 Berkley, Frederick, Murton Colliery, near Sunderland ... ... Dec. 11, 1882
19 Berkley, R. W., Marley Hill, Whickham, R.S.O., Co. Durham ... Feb. 14, 1874
20 Bewick, T. B., Hebburn, Newcastle-on-Tyne ... ... Mar. 7, 1874
21 Bird, W. J., Wingate, Co. Durham ... ... Nov. 6, 1875

ELECTED.

22 BLACKETT, W. C., Jun., Kimblesworth Colliery, Chester-le-Street ... Nov. 4, 1876
23 BOUCHER, A. S., La Salada puerto Bertio, E de Antioguia, United States of Colombia, S.A. ... ... Aug. 4, 1883
24 BRAMWELL, HUGH, Mining Offices, Marsden, South Shields ... ... Oct. 4, 1879
25 BROUGH, THOMAS, Seaham Colliery, Sunderland ... ... Feb. 1, 1873
26 BROWN, C. GILPIN, Hetton Colliery, Fence Houses ... ... Nov. 4, 1876
27 BROWN, M. WALTON, 3, Summerhill Terrace, Newcastle-on-Tyne *(Member of Council)* ... ... Oct. 7, 1871
28 BROWN, ROBERT M., Norwood Colliery, *via* Darlington ... ... April 10, 1886
29 BRUCE, JOHN, Port Mulgrave, Hinderwell, R.S.O., Yorkshire ... Feb. 14, 1874
30 BULMAN, H. F., Broomside Colliery, near Durham ... ... May 2, 1874
31 BUNNING, C. Z., Warora Colliery, Central Provinces, India ... ... Dec. 6, 1873
32 BURDON, A. E., Hartford House, Cramlington, Northumberland ... Feb. 10, 1883

33 CABRERA, FIDEL, c/o H. Kendall & Son, 12, Great Winchester Street, London... ... ... Oct. 6, 1877
34*CANDLER, T. E., F.G.S., Canton Club, Canton, China ... ... May 1, 1875
35 CHARLTON, W. A. (of Tangyes Ltd.), 8, Richmond Terrace, Gateshead Nov. 6, 1880
36 CHILDE, HENRY S., Mining Engineer, Wakefield ... ... Feb. 12, 1887
37 CLOUGH, JAMES, Willow Bridge, Choppington, Morpeth ... ... April 5, 1873
38 COCHRANE, RALPH D., Hetton Colliery Offices, Fence Houses ... June 1, 1878
39 COCKSON, CHARLES, Ince Coal and Cannel Co., Ince, Wigan ... ... April 22, 1882
40 COOPER, R. W., Solicitor, Newcastle-on-Tyne ... ... Sept. 4, 1880
41 CRAWFORD, T. W., 32, Poultry, London, E.C. ... ... Dec. 4, 1875
42 CRONE, F. E., Killingworth, Newcastle-on-Tyne ... ... Sept. 2, 1876
43 CURRY, W. THOS., Usworth Hall, Washington Station, R.S.O., Durham Sept. 4, 1880

44 DAKERS, W. R., Croxdale Colliery, Durham ... ... Oct. 14, 1882
45 DAVISON, CHARLES, Cornsay Colliery, near Esh, Durham ... ... Dec. 11, 1882
46 DENNISTON, ROBERT B., 79, Princes Street, Dunedin, New Zealand ... Dec. 11, 1886
47 DODD, M., Lemington, Scotswood-on-Tyne ... ... Dec. 4, 1875
48 DONKIN, WM., Warora Colliery, Wardha Coal State Railway, C.P., India Sept. 2, 1876
49 DOUGLAS, A. S., Stanley Villa, near Crook, *via* Darlington ... ... June 1, 1878
50 DOUGLAS, JOHN, Seghill Colliery, Dudley, Northumberland ... ... April 22, 1882
51 DOUGLAS, JOHN, Jun., Seghill Colliery, Dudley, Northumberland ... April 22, 1882
52 DOUGLAS, M. H., Marsden Colliery, South Shields ... ... Aug. 2, 1879
53 DOYLE, PATRICK, C.E., F.M.S., F.L.S., M.R.A.S., F.G.S., M.S.I., Bengal E.I.R., Chord Line, Sitarampur, India ... ... Mar. 1, 1879
54 DU PRE, F. B., 13, Old Elvet, Durham ... ... Oct. 9, 1886
55 DUMAS, EUGENE LOUIS, Rue St. George, Paris ... ... Dec. 11, 1886
56 DUNN, A. F., Poynton, Stockport, Cheshire ... ... June 2, 1877
57 DURNFORD, H. ST. JOHN, Aldwarke Main Collieries, near Rotherham June 2, 1877

58 EDGE, JOHN H., Coalport Wire Rope and Chain Works, Shifnal, Salop Sept. 7, 1878
59 EDWARDS, F. H., Forth House, Bewick Street, Newcastle-on-Tyne ... June 11, 1887

60 FAIRLEY, JAMES, Craghead and Holmside Collieries, Chester-le-Street Aug. 7, 1880
61 FARROW, JOSEPH, Brotton Mines, Brotton, R.S.O. ... ... Feb. 11, 1882

ELECTED.

62 FERGUSON, D., Cadzow Colliery, Hamilton, N.B. ... ... Dec. 8, 1883
63 FISHER, EDWARD R., Nant Glas, Cross Hands, near Llanelly, So. Wales Aug. 2, 1884
64 FLETCHER, W., Brigham Hill, *via* Carlisle ... ... Oct. 13, 1883
65 FORSTER, THOMAS E., Lesbury, R.S.O., Northumberland ... ... Oct. 7, 1876
66 FRYAR, MARK, Denby Colliery, Derby ... ... Oct. 7, 1876

67 GERRARD, JAMES, 19, King Street, Wigan ... ... Mar. 3, 1873
68 GILCHRIST, J. R., Durham Main Colliery, Durham ... ... Feb. 3, 1877
69 GREENER, HENRY, South Pontop Colliery, Annfield Plain ... ... Dec. 11, 1882
70 GREENER, T. Y., Hucknall Torkard Collieries, near Nottingham ... July 2, 1872
71 GRESLEY, W. S., F.G.S., Assoc. Inst. C.E., Overseile, Ashby-de-la-Zouch Oct. 5, 1878

72 HADDOCK, W. T., Jun., Ryhope Colliery, Sunderland ... ... Oct. 7, 1876
73 HAGGIE, PETER SINCLAIR, Gateshead-on-Tyne ... ... April 14, 1883
74 HALLAS, G. H., Wigan and Whiston Coal Co., Limited, Prescot ... Oct. 7, 1876
75 HALSE, EDWARD, 15, Clarendon Road, Notting Hill, London, W. ... June 13, 1885
76 HAMILTON, E., Rig Wood, Saltburn-by-the-Sea ... ... Nov. 1, 1873
77 HARRIS, W. S., Kibblesworth, Gateshead-on-Tyne ... ... Feb. 14, 1874
78 HEDLEY, E., Rainham Lodge, The Avenue, Beckenham, Kent ... Dec. 2, 1871
79 HEDLEY, SEPT. H., East Gawber Colliery, Barnsley ... ... Feb. 15, 1879
80 HEDLEY, T. F. jun., Valuer, Sunderland ... ... April 23, 1887
81 HENDERSON, C. W. C., The Riding, Hexham ... ... Dec. 11, 1882
82 HENDY, J. C. B., Stanton Iron Co's. Collieries, Pleasley, near Mansfield, Notts. ... ... Sept. 2, 1876
83 HESLOP, SEPTIMUS, Asansol, E.I.R., Bengal, India ... ... Dec. 4, 1880
84 HILL, WILLIAM, Carterthorne Colliery Offices, Witton-le-Wear ... June 9, 1883
85 HOLME, JAMES, McKenzie Block, Winnipeg, Manitoba, Canada ... June 12, 1886
86 HOOPER, FRED. G., South Derwent Coll., Annfield Plain, Lintz Green Feb. 14, 1885
87 HUMBLE, JOICEY, Wire Rope Manufac., Byker Ropery, Newcastle ... Mar. 3, 1877
88 HUMBLE, ROBERT, Wire Rope Manufac., Byker Ropery, Newcastle... Sept. 2, 1876
89 HUMBLE, STEPHEN, 5, Westminster Chambers, Victoria St., London, S.W. Oct. 6, 1877
90 JEFFCOCK, CHARLES E., Birley Collieries, Sheffield ... ... Feb. 10, 1883
91 JEPSON, H., 42, South Street, Durham ... ... July 2, 1872
92*JOBLING, THOS. E., Croft Villa, Blyth, Northumberland ... ... Oct. 7, 1876
93 JOHNSON, F. D., Aykleyheads, Durham ... ... Feb. 10, 1883
94 JOHNSON, W., Abram Colliery, Wigan ... ... Feb. 14, 1874

95 KIRKUP, PHILIP, Cornsay Colliery Office, Esh, near Durham ... Mar. 2, 1878
96 KIRTON, HUGH, Waldridge Colliery, Chester-le-Street ... ... April 7, 1877

97 LAVERICK, JOHN WALES, Tow Law Colliery Office, Tow Law, R.S.O., Co. Durham ... ... Dec. 11, 1882
98 LEE, JOHN F., Castle Eden Colliery, County Durham... ... ... June 13, 1885
99 LIDDELL, J. M., 3, Victoria Villas, Newcastle-on-Tyne ... ... Mar. 6, 1875
100 LIDDELL, JOHN, Coal Owner, Newcastle-on-Tyne ... ... Dec. 11, 1882
101 LINDSAY, C. S., Usworth, *via* Washington, R.S.O., Co. Durham ... Mar. 4, 1876
102 LISLE, J., Washington Colliery, County Durham ... ... July 2, 1872

ELECTED.

103 LIVEING, E. H., 52, Queen Anne Street, Cavendish Square, London, W. Sept. 1, 1877
104 LONGBOTHAM, R. H., Brynkinalt Colliery, Chirk, Wales ... ... Sept. 2, 1876

105 MACCABE, H. O., Russell Vale, Wollongong, New South Wales ... Sept. 7, 1878
106 MACKINLAY, T. B., West Pelton Colliery, Chester-le-Street ... ... Nov. 1, 1879
107 MADDISON, THOS. R., The Knowle, Mirfield ... ... Mar. 3, 1877
108 MAKEPEACE, H. R., Evenwood, &c., Collieries, near Bishop Auckland Mar. 3, 1877
109 MARKHAM, G. E., Howlish Offices, Bishop Auckland ... ... Dec. 4, 1875
110 MATTHEWS, J., Messrs. R. & W. Hawthorn, Newcastle-on-Tyne ... April 11, 1885
111 MCKINLESS, JAMES, 1, Gore Street, Greenheys, Manchester ... ... Oct. 9, 1886
112*MERIVALE, W., Kirwee, Manikpur, Bhopal, Central India ... ... Mar. 5, 1881
113 MILLER, D. S., Cheadle, Staffordshire ... ... Nov. 7, 1874
114*MILLER, N., 31, Hyde Lane, Hyde, near Manchester ... ... Oct. 5, 1878
115 MOORE, WILLIAM, Upleatham Mines, Upleatham, R.S.O. ... ... Nov. 19, 1881
116 MOREING, C. A., Suffolk House, Lawrence Pountney Hill, London, E.C. Nov. 7, 1874
117 MORISON, JOHN, Newbattle Collieries, Dalkeith, N.B. ... ... Dec. 4, 1880
118 MULHOLLAND, M. L., Broomhill, Acklington, Northumberland ... Dec. 11, 1886
119 MURTON, CHARLES J., Jesmond Villas, Newcastle-on-Tyne ... ... Mar. 6, 1880
120 MUSGRAVE, HENRY, Havercroft Main Colliery, Wakefield ... ... June 12, 1886

121 NICHOL, WM., Boldon Colliery, Newcastle-on-Tyne ... ... Oct. 9, 1886

122 ORNSBY, R. E., Seaton Delaval Colliery, Northumberland ... ... Mar. 6, 1875

123 PALMER, HENRY, East Howle Colliery, near Ferryhill ... ... Nov. 2, 1878
124 PARSONS, HON. CHARLES ALGERNON, Elvaston Hall, Ryton-on-Tyne
(Member of Council)... ... ... June 12, 1886
125 PEAKE, C. E., Eskell Chambers, Nottingham ... ... Nov. 3, 1877
126 PEAKE, R. C., Stoke Lodge, Bletchley, Bucks. ... ... Feb. 7, 1880
127 PEARSON, GEORGE R., 10, Bensham Crescent, Gateshead ... ... Oct. 10, 1885
128*PEASE, ARTHUR, Darlington ... ... Dec. 11, 1882
129 PREST, J. J., Mining Offices, Marsden, South Shields ... ... May 1, 1875
130 PREST, T., Bedlington Colliery, R.S.O., Northumberland ... ... June 14, 1884
131 PRICE, S. R., Cottam Colliery, Barlbro, near Chesterfield ... ... Nov. 3, 1877
132 PROCTOR, C. P., Shibden Hall Collieries, near Halifax, Yorkshire ... Oct. 7, 1876
133 PROUD, JOSEPH, South Hetton Colliery Offices, Sunderland ... ... Oct. 14, 1882

134 RATHBONE, EDGAR P., 2, Great George Street, Westminster, London Mar. 7, 1874
135 RIDLEY, Sir MATTHEW WHITE, Bart., M.P., Blagdon, Northumberland Feb. 10, 1883
136 ROBINSON, FRANK, The Nunnery, Orrell Mount, Wigan ... ... Sept. 2, 1876
137 ROBSON, T. O., Bensham Crescent, Gateshead-on-Tyne ... ... Sept. 11, 1875
138 ROUTLEDGE, W. H., Cliffe House, Clowne, Chesterfield ... ... Oct. 7, 1876

139*SAISE, WALTER, D. Sc. (Lond.), M. Inst. C.E., Manager E.I.R. Collieries, Giridih, Bengal, India ... ... Nov. 3, 1877
140 SAWYER, A. R., Ass. R.S.M., Newcastle, Staffordshire ... ... Dec. 6, 1873
141 SCURFIELD, GEO. J., Hurworth-upon-Tees, Darlington ... ... Dec. 11, 1882
142 SHIPLEY, T., Woodland Colliery Office, Woodland, Butterknowle, R.S.O., Co. Durham ... ... Aug. 2, 1884

ELECTED.

143 SIMPSON, F. L. G., Peases' West Collieries, Crook, by Darlington ... Dec. 13, 1884
144 SMITH, EUSTACE, Wire Rope Manufacturer and Shipbuilder, Newcastle June 11, 1887
145 SMITH, THOS. READER, M.E., Cambridge House, Drayton Place, Tamworth Road, Croydon ... ... Feb. 5, 1881
146 SNOWBALL, JOSEPH, Seaton Burn House, Dudley, Northumberland ... Feb. 10, 1883
147 SOUTHERN, E. O., Ashington Colliery, near Morpeth ... ... Dec. 5, 1874
148 SPENCE, R. F., Cramlington ... ... Nov. 2, 1878
149 STOBART, F., Pensher House, Fence Houses ... ... Aug. 2. 1873
150 STOBBS, FRANK, 1, Queen Street, Newcastle-on-Tyne ... ... Oct. 1, 1881
151 STOKER, ARTHUR P., Birtley, near Chester-le-Street ... ... Oct. 6, 1877

152 TELFORD, W. H., Hartford Coll., Cramlington, R.S.O., Northumberland Oct. 3, 1874
153 THOMPSON, CHARLES LACY, Milton Hall, Carlisle ... ... Feb. 10, 1883
154 TODD, JOHN T., Hamsteels, near Durham ... ... Nov. 4, 1876

155 VITANOFF, GEO. N., Sophia, Bulgaria ... ... April 22, 1882

156 WAIN, WM. HOLT, Podmore Hall Collieries, Newcastle-under-Lyne .. Feb. 12, 1887
157 WALTERS, HARGRAVE, Birley Collieries, near Sheffield ... ... June 4, 1881
158 WALTON, J. COULTHARD, Writhlington Collieries, Radstock, *via* Bath Nov. 7, 1874
159* WARD, T. H., F.G.S., Assistant Manager, E.I.R. Collieries, Giridi, Bengal, India ... ... Aug. 7, 1883
160 WARDLE, EDWARD, Craghead Colliery, Chester-le-Street ... ... Feb. 5, 1881
161 WATKYN-THOMAS, W., M.E., Mineral Office, Cockermouth Castle ... Feb. 10, 1883
162 WEBSTER, H. INGHAM, Morton House, Fence Houses ... ... April 14, 1883
163 WEEKS, R. L., Willington, Co. Durham ... ... June 10, 1882
164 WHITE, C. E., Hebburn Colliery, near Newcastle-on-Tyne ... ... Nov. 4, 1876
165 WIGHT, EDWD. S., c/o R. M. Wight, Askam-in-Furness, Lancashire Dec. 12, 1885
166 WILSON, J. D., Ouston House, Chester-le-Street ... ... Sept. 11, 1873
167 WILSON, JOHN R., Swaithe, near Barnsley ... ... June 9, 1883
168 WORMALD, C. F., Mayfield Villa, Saltwell, Gateshead-on-Tyne ... Dec. 8, 1885

Students.

1 ANDERSON, R. S., Elswick Colliery, Newcastle-on-Tyne ... ... June 9, 1883

2 BARRASS, M., Tudhoe Colliery, Spennymoor ... ... Dec. 10, 1883
3 BAUMGARTNER, W. O., Nettlebed Vicarage, Henley-on-Thames ... Sept. 6, 1879
4 BIRD, HARRY, Mexico ... ... April 7, 1877
5 BLAKELEY, A. B., Soothill Wood Colliery Co., Limited, near Batley... Feb. 15, 1879
6 BROWN, WESTGARTH F., Marsden Colliery, South Shields ... ... Oct. 9, 1886

7 CHANDLEY, CHARLES, Latchford, Warrington, Lancashire ... ... Nov. 6, 1880
8 COLE, COLLIN, Broomfield, Newcastle-on-Tyne ... ... Oct. 18, 1882
9 CRAWFORD, JAMES MILL, Murton Colliery, near Sunderland ... Dec. 11, 1882

ELECTED.

10 DEPLEDGE, M. F., Satley Vicarage, Tow Law, R.S.O., Co. Durham ... April 7, 1877

11 EVANS, DAVID L., Messrs. Dalziel & Evans, Cardiff ... ... May 4, 1878

12 FERENS, FREDERICK J., Silksworth Colliery, Sunderland ... ... Dec. 4, 1880
13 FORSTER, C. W., 6, Ellison Place, Newcastle-on-Tyne ... ... June 10, 1882
14 FUTERS, THOMAS, 97, Stanhope Street, Newcastle-on-Tyne ... ... Feb. 12, 1887

15 GALLWEY, A. P., Ruby and Dunderburg Mining Co., Eureka, Nevada, U.S. ... ... Oct. 2, 1880
16 GORDON, CHAS. ... ... May 5, 1877
17 GREIG, J., Eston Mines, Middlesbro'-on-Tees ... ... Feb. 5, 1881

18 HAGGIE, DOUGLAS, Thorncliffe Iron Works, Sheffield ... ... April 14, 1883
19 HARE, SAMUEL, Brymbo Co., near Wrexham, North Wales ... ... Aug. 2, 1879
20 HARRISON, R. W., Public Wharf, Leicester ... ... Mar. 3, 1877
21 HAY, W., Jun., Nostell Colliery, Wakefield ... ... Dec. 10, 1883
22 HESLOP, THOMAS, Storey Lodge Colliery, Cockfield, *via* Darlington ... Oct. 2, 1880
23 HILL, LEONARD, Newport Wire Mills, Middlesbro' ... ... Oct. 6, 1877
24 HOOPER, EDWARD, The Grange, Claines, Worcester ... ... June 4, 1881
25 HOWARD, WALTER, c/o F. W. Schwager, Coronel, Chili ... ... April 13, 1878
26 HUDSON, JOSEPH G. S., Albion Mines, Pictou County, Nova Scotia ... Mar. 2, 1878
27 HURST, GEO., Seaton Delaval Colliery, Northumberland ... ... April 14, 1883
28 HUTT, E. H., Medomsley, near Newcastle-on-Tyne ... ... Aug. 4, 1883

29 KAYLL, A. C., Gosforth, Newcastle-on-Tyne ... ... Oct. 7, 1876
30 KIRKHOUSE, E. G., 1, Edith Street, Consett, Co. Durham ... ... Aug. 3, 1878

31 LISHMAN, R. R., Celynen Colliery, Abercarne, *via* Newport, Mon. ... June 9, 1883

32 MCLAREN, B., Heddon Coal and Fire Brick Co., Wylam-on-Tyne ... Dec. 10, 1883
33 MCMURTRIE, G. E. J., 42, Clough Road, Masbro', Rotherham ... Aug. 2, 1884
34 MITTON, A. D., Houghton-le-Spring, Fence Houses ... ... June 9, 1883
35 MURRAY, W. C., Weed Park, Dipton, *via* Lintz Green Station ... Oct. 4, 1879

36 NICHOLSON, A. D., Eldon Colliery, Co. Durham ... ... June 13, 1885
37 NICHOLSON, J. H., Sandfield, West Boldon, East Boldon R.S.O., Co. Durham ... ... Oct. 1, 1881

38 OATES, ROBERT J. W., E.I.R. Collieries, Giridi, Bengal, India ... Feb. 10, 1883

39 PATTISON, JOS. W., Londonderry Offices, Seaham Harbour ... ... Feb. 15, 1879
40 PEART, A. W., 70, Caeharris, Dowlais, South Wales ... ... Nov. 4, 1876
41 PEASE, J. F., Pierremont, Darlington ... ... June 9, 1883
42 PIKE, ARNOLD, Furzebrook, Wareham, Dorsetshire ... ... Feb. 5, 1881
43 POTTER, E. A., Cramlington House, Northumberland ... ... Feb. 6, 1875

ELECTED.

44 PRINGLE, H. A., Barrow Collieries, Barnsley, Yorkshire ... Oct. 2, 1880
45 PRINGLE, HY. GEO., Tanfield Lea Coll., Lintz Green Station, Newcastle Dec. 4, 1880

46 REDMAYNE, R. A. S., Hetton Collieries, near Fence Houses ... Dec. 13, 1881
47 RICHARDSON, RALPH, Field House, West Rainton, Fence Houses ... June 9, 1883
48 RIDLEY, WM., So. Tanfield Coll., Stanley, R.S.O., Newcastle-on-Tyne Dec. 11, 1882
49 RUTHERFORD, R., So. Derwent Colliery, Annfield Plain, Lintz Green Feb. 14, 1885

50 SCARTH, R. W., Cridling Stubbs, Knottingley ... Dec. 4, 1875
51 SCOTT, JOSEPH SAMUEL, East Hetton Colliery, Coxhoe, Co. Durham Nov. 19, 1881
52 SCOTT, WALTER, Cornsay Colliery, Lanchester ... Sept. 6, 1879
53 SCOTT, WM., Brancepeth Colliery Offices, Willington, Co. Durham Mar. 4, 1876
54 SHUTE, WM. ASHLEY, Westoe, South Shields ... April 11, 1885
55 SIMPSON, F. R., Hedgefield House, Blaydon-on-Tyne ... Aug. 4, 1883
56 SMITH, THOS., Leadgate, Co. Durham ... Feb. 15, 1879
57 SMITH, T. F., Jun., c/o Mr. Parry, Grocer and Draper, Littledean, Newnham ... May 5, 1877
58 STEAVENSON, C. H., Durham ... April 14, 1883
59 STOBART, H. T., Mill View Cottage, Southwick, Sunderland ... Oct. 2, 1880
60 SYKES, FRANK K., Esh Colliery, Durham ... Feb. 13, 1886

61 TODNER, W. J. S. ... Sept. 6, 1879

62 WAUGH, C. L., Ffalda Steam Coal Colliery, Garw Valley, nr. Bridgend Nov. 19, 1881

63 YEOMAN, THOMAS, 1, Westfield Terrace, Loftus-in-Cleveland ... Feb. 14, 1885

Subscribers under Bye-law 9.

1 Ashington Colliery, Newcastle-on-Tyne.
2 Birtley Iron Company, Birtley.
3 Haswell Colliery, Fence Houses.
4 Hetton Collieries, Fence Houses.
5 Lambton Collieries, Fence Houses.
6 Londonderry Collieries, Seaham Harbour.
7 Marquess of Bute.
8 North Hetton Colliery, Fence Houses.
9 Ryhope Colliery, near Sunderland.
10 Seghill Colliery, Northumberland.
11 South Hetton and Murton Collieries.
12 Stella Colliery, Hedgefield, Blaydon-on-Tyne.
13 Throckley Colliery, Newcastle-on-Tyne.
14 Victoria Garesfield Colliery, Lintz Green.
15 Wearmouth Colliery, Sunderland.

CHARTER

OF

THE NORTH OF ENGLAND

Institute of Mining and Mechanical Engineers.

FOUNDED 1852.

INCORPORATED NOVEMBER 28TH, 1876.

Victoria, by the Grace of God, of the United Kingdom of Great Britain and Ireland, Queen, Defender of the Faith, TO ALL TO WHOM THESE PRESENTS SHALL COME, GREETING:

WHEREAS it has been represented to us that NICHOLAS WOOD, of Hetton, in the County of Durham, Esquire (since deceased); THOMAS EMERSON FORSTER, of Newcastle-upon-Tyne, Esquire (since deceased); SIR GEORGE ELLIOT, Baronet (then George Elliot, Esquire), of Houghton Hall, in the said County of Durham, and EDWARD FENWICK BOYD, of Moor House, in the said County of Durham, Esquire, and others of our loving subjects, did, in the year one thousand eight hundred and fifty-two, form themselves into a Society, which is known by the name of THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, having for its objects the Prevention of Accidents in Mines and the Advancement of the Sciences of Mining and Engineering generally, of which Society LINDSAY WOOD, of Southill, Chester-le-Street, in the County of Durham, Esquire, is the present President. AND WHEREAS it has been further represented to us that the Society was not constituted for gain, and that neither its projectors nor Members derive nor have derived pecuniary profit from its prosperity; that it has during its existence of a period of nearly a quarter of a century steadily devoted itself to the preservation of human life and the safer development of mineral property; that it has contributed substantially and beneficially to the prosperity of the country and the welfare and happiness of the working members of the community; that the Society has since its establishment diligently pursued its aforesaid objects, and in so doing has made costly experiments

and researches with a view to the saving of life by improvements in the ventilation of mines, by ascertaining the conditions under which the safety lamp may be relied on for security; that the experiments conducted by the Society have related to accidents in mines of every description, and have not been limited to those proceeding from explosions; that the various modes of getting coal, whether by mechanical appliances or otherwise, have received careful and continuous attention, while the improvements in the mode of working and hauling belowground, the machinery employed for preventing the disastrous falls of roof underground, and the prevention of spontaneous combustion in seams of coal as well as in cargoes, and the providing additional security for the miners in ascending and descending the pits, the improvements in the cages used for this purpose, and in the safeguards against what is technically known as "overwinding," have been most successful in lessening the dangers of mining, and in preserving human life; that the Society has held meetings at stated periods, at which the results of the said experiments and researches have been considered and discussed, and has published a series of Transactions filling many volumes, and forming in itself a highly valuable Library of scientific reference, by which the same have been made known to the public, and has formed a Library of Scientific Works and Collections of Models and Apparatus, and that distinguished persons in foreign countries have availed themselves of the facilities afforded by the Society for communicating important scientific and practical discoveries, and thus a useful interchange of valuable information has been effected; that in particular, with regard to ventilation, the experiments and researches of the Society, which have involved much pecuniary outlay and personal labour, and the details of which are recorded in the successive volumes of the Society's Transactions, have led to large and important advances in the practical knowledge of that subject, and that the Society's researches have tended largely to increase the security of life; that the Members of the Society exceed 800 in number, and include a large proportion of the leading Mining Engineers in the United Kingdom. AND WHEREAS in order to secure the property of the Society, and to extend its useful operations, and to give it a more permanent establishment among the Scientific Institutions of our Kingdom, we have been besought to grant to the said LINDSAY WOOD, and other the present Members of the Society, and to those who shall hereafter become Members thereof, our Royal Charter of Incorporation. NOW KNOW YE that we, being desirous of encouraging a design so laudable and salutary of our special grace, certain knowledge, and mere motion, have willed granted, and declared, and

do, by these presents, for us, our heirs, and successors, will, grant, and declare, that the said LINDSAY WOOD, and such others of our loving subjects as are now Members of the said Society, and such others as shall from time to time hereafter become Members thereof, according to such Bye-laws as shall be made as hereinafter mentioned, and their successors, shall for ever hereafter be, by virtue of these presents, one body, politic and corporate, by the name of "THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS," and by the name aforesaid shall have perpetual succession and a Common Seal, with full power and authority to alter, vary, break, and renew the same at their discretion, and by the same name to sue and be sued, implead and be impleaded, answer and be answered unto, in every Court of us, our heirs and successors, and be for ever able and capable in the law to purchase, acquire, receive, possess, hold, and enjoy to them and their successors any goods and chattels whatsoever, and also be able and capable in the law (notwithstanding the statutes and mortmain) to purchase, acquire, possess, hold and enjoy to them and their successors a hall or house, and any such other lands, tenements, or hereditaments whatsoever, as they may deem requisite for the purposes of the Society, the yearly value of which, including the site of the said hall or house, shall not exceed in the whole the sum of three thousand pounds, computing the same respectfully at the rack rent which might have been had or gotten for the same respectfully at the time of the purchase or acquisition thereof. AND WE DO HEREBY GRANT our especial licence and authority unto all and every person and persons and bodies politic and corporate, otherwise competent, to grant, sell, alien, convey or devise in mortmain unto and to the use of the said Society and their successors, any lands, tenements, or hereditaments not exceeding with the lands, tenements or hereditaments so purchased or previously acquired such annual value as aforesaid, and also any moneys, stocks, securities, and other personal estate to be laid out and disposed of in the purchase of any lands, tenements, or hereditaments not exceeding the like annual value. AND WE FURTHER will, grant, and declare, that the said Society shall have full power and authority, from time to time, to sell, grant, demise, exchange and dispose of absolutely, or by way of mortgage, or otherwise, any of the lands, tenements, hereditaments and possessions, wherein they have any estate or interest, or which they shall acquire as aforesaid, but that no sale, mortgage, or other disposition of any lands, tenements, or hereditaments of the Society shall be made, except with the approbation and concurrence of a General Meeting. And our will and pleasure is, and we further grant and declare that for the better rule

and government of the Society, and the direction and management of the concerns thereof, there shall be a Council of the Society, to be appointed from among the Members thereof, and to include the President and the Vice-Presidents, and such other office-bearers or past office-bearers as may be directed by such Bye-laws as hereinafter mentioned, but so that the Council, including all *ex-officio* Members thereof, shall consist of not more than forty or less than twelve Members, and that the Vice-Presidents shall be not more than six or less than two in number. AND WE DO HEREBY FURTHER will and declare that the said LINDSAY WOOD shall be the first President of the Society, and the persons now being the Vice-Presidents, and the Treasurer and Secretary, shall be the first Vice-Presidents, and the first Treasurer and Secretary, and the persons now being the Members of the Council shall be the first Members of the Council of the Society, and that they respectfully shall continue such until the first election shall be made at a General Meeting in pursuance of these presents. AND WE DO HEREBY FURTHER will and declare that, subject to the powers by these presents vested in the General Meetings of the Society, the Council shall have the management of the Society, and of the income and property thereof, including the appointment of officers and servants, the definition of their duties, and the removal of any of such officers and servants, and generally may do all such acts and deeds as they shall deem necessary or fitting to be done, in order to carry into full operation and effect the objects and purposes of the Society, but so always that the same be not inconsistent with, or repugnant to, any of the provisions of this our Charter, or the Laws of our Realm, or any Bye-law of the Society in force for the time being. AND WE DO FURTHER will and declare that at any General Meeting of the Society, it shall be lawful for the Society, subject as hereinafter mentioned, to make such Bye-laws as to them shall seem necessary or proper for the regulation and good government of the Society, and of the Members and affairs thereof, and generally for carrying the objects of the Society into full and complete effect, and particularly (and without its being intended hereby to prejudice the foregoing generality), to make Bye-laws for all or any of the purposes hereinafter mentioned, that is to say: for fixing the number of Vice-Presidents, and the number of Members of which the Council shall consist, and the manner of electing the President and Vice-Presidents, and other Members of the Council, and the period of their continuance in office, and the manner and time of supplying any vacancy therein; and for regulating the times at which General Meetings of the Society and Meetings of the Council shall be held, and for convening the same and regulating the proceedings thereat, and

for regulating the manner of admitting persons to be Members of the Society, and of removing or expelling Members from the Society, and for imposing reasonable fines or penalties for non-performance of any such Bye-laws, or for disobedience thereto, and from time to time to annul, alter, or change any such Bye-laws so always that all Bye-laws to be made as aforesaid be not repugnant to these presents, or to any of the laws of our Realm. AND WE DO FURTHER will and declare that the present Rules and Regulations of the Society, so far as they are not inconsistent with these presents, shall continue in force, and be deemed the Bye-laws of the Society until the same shall be altered by a General Meeting, provided always that the present Rules and Regulations of the Society and any future Bye-laws of the Society so to be made as aforesaid shall have no force or effect whatsoever until the same shall have been approved in writing by our Secretary of State for the Home Department. IN WITNESS WHEREOF WE HAVE CAUSED THESE OUR LETTERS TO BE MADE PATENT.

Witness Ourself at our Palace, at Westminster, this 28th day of November, in the fortieth year of our reign.

By Her Majesty's Command.

CARDEW.

THE NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

BYE-LAWS

PASSED AT A GENERAL MEETING ON THE 16TH JUNE, 1877.

1.—The members of the North of England Institute of Mining and Mechanical Engineers shall consist of four classes, viz.:—Original Members, Ordinary Members, Associate Members, and Honorary Members, with a class of Students attached.

2.—ORIGINAL MEMBERS shall be those who were Ordinary Members on the 1st of August, 1877.

3.—ORDINARY MEMBERS.—Every candidate for admission into the class of Ordinary Members, or for transfer into that class, shall come within the following conditions:—He shall be more than twenty-eight years of age, have been regularly educated as a Mining or Mechanical Engineer, or in some other recognised branch of Engineering, according to the usual routine of pupilage, and have had subsequent employment for at least five years in some responsible situation as an Engineer, or if he has not undergone the usual routine of pupilage, he must have practised on his own account in the profession of an Engineer for at least five years, and have acquired a considerable degree of eminence in the same.

4.—ASSOCIATE MEMBERS shall be persons practising as Mining or Mechanical Engineers, or in some other recognised branch of Engineering, and other persons connected with or interested in Mining or Engineering.

5.—HONORARY MEMBERS shall be persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society.

6.—Students shall be persons who are qualifying themselves for the profession of Mining or Mechanical Engineering, or some other of the recognised branches of Engineering, and such persons may continue Students until they attain the age of twenty-three years.

7.—The annual subscription of each Original Member, and of each Ordinary Member who was a Student on the 1st of August, 1877, shall be £2 2s., of each Ordinary Member (except as last mentioned) £3 3s., of each Associate Member £2 2s., and of each Student £1 1s., payable in advance, and shall be considered due on election, and afterwards on the first Saturday in August of each year.

8.—Any Member may, at any time, compound for all future subscriptions by a payment of £25, where the annual subscription is £3 3s., and by a payment of £20 where the annual subscription is £2 2s. All persons so compounding shall be Original, Ordinary, or Associate Members for life, as the case may be; but any Associate Member for life who may afterwards desire to become an Ordinary Member for life, may do so, after being elected in the manner described in Bye-law 13, and on payment of the further sum of £5.

9.—Owners of Collieries, Engineers, Manufacturers, and Employers of labour generally, may subscribe annually to the funds of the Institute, and each such subscriber of £2 2s. annually shall be entitled to a ticket to admit two persons to the rooms, library, meetings, lectures, and public proceedings of the Society; and for every additional £2 2s., subscribed annually, two other persons shall be admissible up to the number of ten persons; and each such Subscriber shall also be entitled for each £2 2s. subscription to have a copy of the Proceedings of the Institute sent to him.

10.—In case any Member, who has been long distinguished in his professional career, becomes unable, from ill-health, advanced age, or other sufficient cause, to carry on a lucrative practice, the Council may, on the report of a Sub-Committee appointed for that purpose, if they find good reason for the remission of the annual subscription, so remit it. They may also remit any arrears which are due from a member, or they may accept from him a collection of books, or drawings, or models, or other contributions, in lieu of the composition mentioned in Bye-law 8, and may thereupon constitute him a Life Member, or permit him to resume his former rank in the Institute.

11.—Persons desirous of becoming Ordinary Members shall be proposed and recommended, according to the Form A in the Appendix, in which form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This form must be signed by the proposer and at least five other Members certifying a personal knowledge of the candidate. The proposal so made being delivered to the Secretary, shall be submitted to the Council, who on approving the qualifications shall determine if the candidate is to be presented for ballot, and if it is so deter-

mined, the Chairman of the Council shall sign such approbation. The same shall be read at the next Ordinary General Meeting, and afterwards be placed in some conspicuous situation until the following Ordinary General Meeting, when the candidate shall be balloted for.

12.—Persons desirous of being admitted into the Institute as Associate Members, or Students, shall be proposed by three Members; Honorary Members shall be proposed by at least five Members, and shall in addition be recommended by the Council, who shall also have the power of defining the time during which, and the circumstances under which, they shall be Honorary Members. The nomination shall be in writing, and signed by the proposers (according to the Form B in the Appendix), and shall be submitted to the first Ordinary General Meeting after the date thereof. The name of the person proposed shall be exhibited in the Society's room until the next Ordinary General Meeting, when the candidate shall be balloted for.

13.—Associate Members or Students, desirous of becoming Ordinary Members, shall be proposed and recommended according to the Form C in the Appendix, in which form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This form must certify a personal knowledge of the candidate, and be signed by the proposer and at least two other Members, and the proposal shall then be treated in the manner described in Bye-law 11. Students may become Associate Members at any time after attaining the age of twenty-three on payment of an Associate Member's subscription.

14.—The balloting shall be conducted in the following manner:—Each Member attending the Meeting at which a ballot is to take place shall be supplied (on demand) with a list of the names of the persons to be balloted for, according to the Form D in the Appendix, and shall strike out the names of such candidates as he desires shall not be elected, and return the list to the scrutineers appointed by the presiding Chairman for the purpose, and such scrutineers shall examine the lists so returned, and inform the meeting what elections have been made. No candidate shall be elected unless he secures the votes of two-thirds of the Members voting.

15.—Notice of election shall be sent to every person within one week after his election, according to the Form E in the Appendix, enclosing at the same time a copy of Form F, which shall be returned by the person elected, signed, and accompanied with the amount of his annual subscription, or life composition, within two months from the date of such election, which otherwise should become void.

16.—Every Ordinary Member elected having signed a declaration in the Form F, and having likewise made the proper payment, shall receive a certificate of his election.

17.—Any person whose subscription is two years in arrear shall be reported to the Council, who shall direct application to be made for it, according to the Form G in the Appendix, and in the event of its continuing one month in arrear after such application, the Council shall have the power, after remonstrance by letter, according to the Form H in the Appendix, of declaring that the defaulter has ceased to be a member.

18.—In case the expulsion of any person shall be judged expedient by ten or more Members, and they think fit to draw up and sign a proposal requiring such expulsion, the same being delivered to the Secretary, shall be by him laid before the Council for consideration. If the Council, after due inquiry, do not find reason to concur in the proposal, no entry thereof shall be made in any minutes, nor shall any public discussion thereon be permitted, unless by requisition signed by one-half the Members of the Institute; but if the Council do find good reason for the proposed expulsion, they shall direct the Secretary to address a letter, according to the Form I in the Appendix, to the person proposed to be expelled, advising him to withdraw from the Institute. If that advice be followed, no entry on the minutes nor any public discussion on the subject shall be permitted; but if that advice be not followed, nor an explanation given which is satisfactory to the Council, they shall call a General Meeting for the purpose of deciding on the question of expulsion; and if a majority of the persons present at such Meeting (provided the number so present be not less than forty) vote that such person be expelled, the Chairman of that Meeting shall declare the same accordingly, and the Secretary shall communicate the same to the person, according to the Form J in the Appendix.

19.—The Officers of the Institute, other than the Treasurer and the Secretary, shall be elected from the Original, Ordinary and Associate Members, and shall consist of a President, six Vice-Presidents, and eighteen Councillors, who, with the Treasurer and the Secretary (if Members of the Institute) shall constitute the Council. The President, Vice-Presidents, and Councillors shall be elected at the Annual Meeting in August (except in cases of vacancies) and shall be eligible for re-election, with the exception of any President or Vice-President who may have held office for the three immediately preceding years, and such six Councillors as may have attended the fewest Council Meetings during the past

year; but such Members shall be eligible for re-election after being one year out of office.

20.—The Treasurer and the Secretary shall be appointed by the Council, and shall be removable by the Council, subject to appeal to a General Meeting. One and the same person may hold both these offices.

21.—Each Original, Ordinary, and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members suitable to fill the offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. (See Form K in the Appendix.) A copy of this list shall be posted at least seven days previous to the Annual Meeting, to every Original, Ordinary, and Associate Member; who may erase any name or names from the list, and substitute the name or names of any other person or persons eligible for each respective office; but the number of persons on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The Votes for any Members who may not be elected President or Vice-Presidents shall count for them as Members of the Council. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the Meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

22.—In case of the decease or resignation of any Officer or Officers, the Council, if they deem it requisite that the vacancy shall be filled up, shall present to the next Ordinary General Meeting a list of persons whom they nominate as suitable for the vacant offices, and a new Officer or Officers shall be elected at the succeeding Ordinary General Meeting.

23.—The President shall take the chair at all meetings of the Institute, the Council, and Committees, at which he is present (he being *ex-officio* a member of all), and shall regulate and keep order in the proceedings.

24.—In the absence of the President, it shall be the duty of the senior Vice-President present to preside at the meetings of the Institute, to keep order, and to regulate the proceedings. In case of the absence of the President and of all the Vice-Presidents, the meeting may elect any Member of Council, or in case of their absence, any Member present, to take the chair at the meeting.

25.—The Council may appoint Committees for the purpose of transacting any particular business, or of investigating specific subjects connected with the objects of the Institute. Such Committees shall report to the Council, who shall act thereon as they see occasion.

26.—The Treasurer and the Secretary shall act under the direction and control of the Council, by which body their duties shall from time to time be defined.

27.—The Funds of the Society shall be deposited in the hands of the Treasurer, and shall be disbursed or invested by him according to the direction of the Council.

28.—The Copyright of all papers communicated to, and accepted for printing by the Council, and printed within twelve months, shall become vested in the Institute, and such communications shall not be published for sale or otherwise, without the written permission of the Council.

29.—An Ordinary General Meeting shall be held on the first Saturday of every month (except January and July) at two o'clock, unless otherwise determined by the Council; and the Ordinary General Meeting in the month of August shall be the Annual Meeting, at which a report of the proceedings, and an abstract of the accounts of the previous year, shall be presented by the Council. A Special General Meeting shall be called whenever the Council may think fit, and also on a requisition to the Council, signed by ten or more Members. The business of a Special Meeting shall be confined to that specified in the notice convening it.

30.—At meetings of the Council, five shall be a quorum. The minutes of the Council's proceedings shall be at all times open to the inspection of the Members.

31.—All Past-Presidents shall be *ex-officio* Members of the Council so long as they continue Members of the Institute, and Vice-Presidents who have not been re-elected or have become ineligible from having held office for three consecutive years, shall be *ex-officio* Members of the Council for the following year.

32.—Every question, not otherwise provided for, which shall come before any Meeting, shall be decided by the votes of the majority of the Original, Ordinary, and Associate Members then present.

33.—All papers shall be sent for the approval of the Council at least twelve days before a General Meeting, and after approval, shall be read before the Institute. The Council shall also direct whether any paper read before the Institute shall be printed in the Transactions, and notice shall be given to the writer within one month after it has been read, whether it is to be printed or not.

34.—All proofs of reports of discussions, forwarded to Members for correction, must be returned to the Secretary within seven days from the date of their receipt, otherwise they will be considered correct and be printed off.

35.—The Institute is not, as a body, responsible for the statements and opinions advanced in the papers which may be read, nor in the discussions which may take place at the meetings of the Institute.

36.—Twelve copies of each paper printed by the Institute shall be presented to the author for private use.

37.—Members elected at any meeting between the Annual Meetings shall be entitled to all papers issued in that year, so soon as they have signed and returned Form F, and paid their subscriptions.

38.—The Transactions of the Institute shall not be forwarded to Members whose subscriptions are more than one year in arrear.

39.—No duplicate copies of any portion of the Transactions shall be issued to any of the Members unless by written order from the Council.

40.—Invitations shall be forwarded to any person whose presence at the discussions the Council may think advisable, and strangers so invited shall be permitted to take part in the proceedings but not to vote. Any Member of the Institute shall also have power to introduce two strangers (see Form L) to any General Meeting, but they shall not take part in the proceedings except by permission of the Meeting.

41.—No alteration shall be made in the Bye-laws of the Institute, except at the Annual Meeting, or at a Special Meeting for that purpose, and the particulars of every such alteration shall be announced at a previous Ordinary Meeting, and inserted in its minutes, and shall be exhibited in the room of the Institute fourteen days previous to such Annual or Special Meeting, and such Meeting shall have power to adopt any modification of such proposed alteration of the Bye-laws.

Approved,
R. ASSHETON CROSS.

Whitehall,
2nd July, 1877.

APPENDIX TO THE BYE-LAWS.

[FORM A.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being upwards of twenty-eight years of age, and desirous of being elected an Ordinary Member of the North of England Institute of Mining and Mechanical Engineers, I recommend him from *personal knowledge* as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-law 3.*]

On the above grounds, I beg leave to propose him to the Council as a proper person to be admitted an Ordinary Member.

Signed_____ Member.

Dated this day of 18

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted an ordinary Member.

FROM PERSONAL KNOWLEDGE.

_____
_____
_____ } Five Members.
_____
_____

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as a of the North of England Institute of Mining and Mechanical Engineers.

Signed_____ Chairman.

Dated this day of 18

[FORM B.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being desirous of admission into the North of England Institute of Mining and Mechanical Engineers, we, the undersigned, propose and recommend that he shall become [an Honorary Member, or an Associate Member, or a Student] thereof.

_____
_____
_____ } Three* Members.
_____
_____

* If an Honorary Member, five signatures are necessary, and the following Form must be filled in by the Council.

Dated this day of 18

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Honorary Member of the North of England Institute of Mining and Mechanical Engineers.

Signed _____ Chairman.

Dated day of 18

[FORM C.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being at present a of the North of England Institute of Mining and Mechanical Engineers, and upwards of twenty-eight years of age, and being desirous of becoming an Ordinary Member of the said Institute, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, because—

[*Here specify distinctly the Qualifications of the Candidate according to the spirit of Bye-law 3.*]

On the above grounds, I beg leave to propose him to the Council as a proper person to be admitted an Ordinary Member.

Signed _____ Member.

Dated this . day of 18

We, the undersigned, concur in the above recommendation, being

convinced that A. B. is in every respect a proper person to be admitted an Ordinary Member.

FROM PERSONAL KNOWLEDGE.

_____ } Two
_____ } Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Ordinary Member of the North of England Institute of Mining and Mechanical Engineers.

Signed _____ Chairman.

Dated day of 18

[FORM D.]

List of the names of persons to be balloted for at the Meeting on , the day of 18

ORDINARY MEMBERS:—

_____

_____

_____

ASSOCIATE MEMBERS:—

_____

_____

HONORARY MEMBERS:—

_____

_____

STUDENTS:—

_____

_____

Strike out the names of such persons as you desire should *not* be elected, and hand the list to the Chairman.

[FORM E.]

SIR,—I beg leave to inform you that on the day of you were elected a of the North of England Institute of Mining and Mechanical Engineers, but in conformity with its Rules your election cannot be confirmed until the enclosed form be returned to me

with your signature, and until your first annual subscription be paid, the amount of which is £ , or, at your option, the life-composition of £

If the subscription is not received within two months from the present date, the election will become void under Bye-law 15.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM F.]

I, the undersigned, being elected a of the North of England Institute of Mining and Mechanical Engineers, do hereby agree that I will be governed by the Charter and Bye-laws of the said Institute for the time being; and that I will advance the objects of the Institute as far as shall be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to be a Member.

Witness my hand this day of 18

[FORM G.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to draw your attention to Bye-law 17, and to remind you that the sum of £ of your annual subscriptions to the funds of the Institute remains unpaid. and that you are in consequence in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Article above referred to.

I am, Sir,

Yours faithfully,

Secretary

Dated 18

[FORM H.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you, that in consequence of non-payment of your arrears of subscription, and in pursuance of Bye-law 17, the Council have determined that unless payment of the amount £ is made previous to the day of next, they will proceed to declare that you have ceased to be a Member of the Institute.

But, notwithstanding this declaration, you will remain liable for payment of the arrears due from you.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM I.]

SIR,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you that, upon mature consideration of a proposal which has been laid before them relative to you, they feel it their duty to advise you to withdraw from the Institute, or otherwise they will be obliged to act in accordance with Bye-law 18.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM J.]

SIR,—It is my duty to inform you that, under a resolution passed at a Special General Meeting of the North of England Institute of Mining and Mechanical Engineers, held on the day of 18 , according to the provisions of Bye-law 18 you have ceased to be a Member of the Institute.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM K.]

BALLOTING LIST.

Ballot to take place at the Meeting of 18 at Two o'Clock.

PRESIDENT—ONE NAME only to be returned, or the vote will be lost.

——— President for the current year eligible for re-election.

——— } New Nominations.

VICE-PRESIDENTS—SIX NAMES only to be returned, or the vote will be lost.

The Votes for any Members who may not be elected as President or Vice-Presidents will count for them as other Members of the Council.

——— } Vice-Presidents for the current year eligible for re-election.

——— } New Nominations.

COUNCIL—EIGHTEEN NAMES only to be returned, or the vote will be lost.

——— } Members of the Council for the current year eligible for re-election.

——— } New Nominations.

Any list returned with a greater number of Names than
ONE PRESIDENT,
SIX VICE-PRESIDENTS,
EIGHTEEN COUNCILLORS,
Will be rejected by the Scrutineers as informal, and the Votes will consequently be lost.

Extract from Bye-law 21.

Each Original, Ordinary, and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members suitable to fill the Offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. (See Form K in the Appendix.) A copy of this list shall be posted at least seven days

previous to the Annual Meeting, to every Original, Ordinary, and Associate Member; who may erase any name or names from the list, and substitute the name or names of any other person or persons eligible for each respective office; but the number of persons on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the Scrutineers. The votes for any Members who may not be elected President or Vice-Presidents shall count for them as Members of the Council. The Chairman shall appoint four Scrutineers, who shall receive the balloting papers, and after making the necessary scrutiny destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the Meeting, so as to be received before the appointment of the Scrutineers for the election of Officers.

_____

_____

_____

_____

Names substituted for any of the above are to be written in the blank spaces opposite those they are intended to supersede.

The following Members are ineligible from causes specified in Bye-law 19:—

AS PRESIDENT _____

AS VICE-PRESIDENT _____

AS COUNCILLORS _____

[FORM L.]

Admit

of

to the Meeting on Saturday, the

(Signature of Member or Student)

The Chair to be taken at Two o'Clock.

I undertake to abide by the Regulations of the North of England Institute of Mining and Mechanical Engineers, and not to aid in any unauthorised publication of the Proceedings.

(Signature of Visitor)

Not transferable.

NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING, SATURDAY, OCTOBER 9TH, 1886.

SIR LOWTHIAN BELL, BART., PRESIDENT, IN THE CHAIR.

The PRESIDENT said, that this being the first opportunity he had had of meeting the members of the Institute since his election, he thought it only proper to say that he had sincere pleasure in thanking them for the great honour they had conferred upon him, in asking him to fill the distinguished office of presiding over their meetings for the next twelve months. The Council, of course, were responsible for his nomination. He thought that, among the colliery viewers of the district, they would have done well to have chosen some one to be their President who was more conversant with the practical work of a colliery than he could pretend to be. Having urged this excuse upon the members of the Council, and not finding himself listened to, he consented to undertake the duties of President for the year. He could only say that what he lacked in technical knowledge of their particular business, he would endeavour to make amends for by as attentive a discharge of his duties as possible. He thought it necessary that he should state that, in accepting the invitation of the Council, he told them that if this involved his at once preparing an Inaugural Address, he would be unable to undertake the duty. There were certain matters connected with domestic affairs, and other matters, that rendered it impossible for him to do so, and he ventured, therefore, to ask that he might be allowed a few months before having to compose an Address.

The SECRETARY read the minutes of the last meeting, and reported the proceedings of the Council.

The following gentlemen were elected :—

ASSOCIATE MEMBERS—

Mr. F. B. DU PRE, 13, Old Elvet, Durham.

Mr. WILLIAM NICHOL, Boldon Colliery, Newcastle-on-Tyne.

STUDENT—

Mr. WESTGARTH BROWN, Marsden Colliery, South Shields.

The following gentlemen were nominated for election :—

ASSOCIATE MEMBERS—

Mr. ALF. FALCONER BALL, 81, Wharncliffe Street, Newcastle.

Mr. R. B. DENNISTON, 79, Princes Street, Dunedin, New Zealand.

Mr. E. L. DUMAS, Paris.

Mr. MARTIN MULHOLLAND, Broomhill, Acklington.

The following Associate Member was nominated for election as an

ORDINARY MEMBER :—

Mr. C. R. BARRETT, New Seaham, Sunderland.

Mr. J. WILSON SWAN, M.A., read the following paper on "An Improved Electric Safety Lamp for Miners :"—

ON AN IMPROVED ELECTRIC SAFETY-LAMP FOR MINERS.

By J. WILSON SWAN, M.A.

In the discussion on the paper which was read by the writer of this paper at the meeting held on December 12th, 1885, on "A Portable Electric Safety-Lamp for Miners," the absence of any means of indicating the presence of fire-damp was remarked upon by more than one speaker.

In reply to this criticism, the author stated that he hoped in a short time to be able to combine a fire-damp indicator with the lamp, and that, if this could be done, he would show the lamp with this appendage at a subsequent meeting of the Institute; and it is the purpose of this paper to fulfil that promise. The lamps now exhibited are electric lamps, and several of them are furnished with fire-damp indicators.

But before proceeding to describe the gas indicator, it may be as well to call attention to the lamp itself, and to point out the great improvements which have been made in it since it was last shown to the members. First, the battery has been simplified by using only two cells in some cases and four cells in other cases, instead of the seven cells which the battery contained which was formerly shown.

These are now fitted into a solid block of wood, instead of into a case of ebonite. The cell apertures are lined with ebonite as before. The result of this change is, that the lamp is now better able to resist a blow.

Another improvement is, making the cells liquid tight, so that the lamp may be inclined, or even inverted, without leakage.

The lamp has also been reduced in size and weight, and altogether made more like an ordinary safety-lamp in general form.

Plate I., Figs. 4 and 5, show the general form and arrangement of the new lamp, with the gas detecting apparatus attached, and the mode by which the batteries are replenished at the end of each day's use.

Figures 1, 2, 3, show the fire-damp detector. *f* is a glass tube protected by a brass case *e*, provided with lugs by which it is screwed on to the main body of the lamp. *a* is a cover with small holes *b*. This cover is kept on by a small spiral spring *d*, which tends to keep it in the position shown in Fig. 1, allowing the air from the mine to enter freely into the tube *c*. *k* is a little cam or eccentric attached to a small handle. In Fig. 1 it allows the tube *c* to be in communication with

the atmosphere of the pit. When in the position of Fig. 3 that communication is shut off; but in the intermediate position of Fig. 2, not only is the communication shut off, but the platinum wire *h* is switched into connection with the battery and becomes red hot.

The way the machine is used in practice is this :—A small tube is inserted in the little hole *i*, and the operator draws the air with his mouth from the mine through the holes *b*, in the cover *a*, into the tube *c*, until he considers that tube is full. When the cam is in the position shown in Fig. 2, the platinum wire is heated, and the air from the mine is confined in the chamber *c*; the gas is then burned out, and on the cam being placed, as in Fig. 3, the platinum wire is extinguished, and the instrument is allowed to cool, when the coloured liquid shortly rises up the glass *g*, indicating the amount of gas which has been destroyed by the incandescence of the platinum wire.

It is not further necessary to describe Fig. 4 than to state that all the interior portions of the lamp are practically the same as described in the former paper, except that the number of cells is reduced from seven to four. *e* shows the testing apparatus (before described) as attached to the lamp, and *b* is a small plate of tin, which can be detached and held in front of the bull's-eye *d*, so that the light from the lamp can be reflected on the gas detector *e*, and the eye of the observer protected—the ascent of the coloured liquid being observed through the slit *f*.

Fig. 5 shows the mode in which the lamps are charged after the day's work. *b* and *c* are two points standing from positive and negative wires which run along underneath the table, and, entering two small holes in each lamp, become connected with the terminals of the batteries.

The lamps can be easily arranged so that the light may be fitted on the top to facilitate the examination of the sides and roof of the mine. Other lamps have the light on one side for the hewers.

With this reduced weight and size of battery the lamp still gives an illuminating power of more than a candle during the full time of the shift.

There is another point in which the lamp is improved. The terminals are now brought down to the bottom of the battery case, and can be got at for the purpose of making connection with the charging circuit without removing the cover.

Evidently a great number of batteries could be connected with the charging circuit in a very short time by one person.

It was explained before, that the power of the light is simply dependent on the weight of the battery; double weight giving double light, and

so on; so that where an extra amount of light is required, it can easily be had without necessitating a change of design in the lamp, or in any way lessening safety.

The capability possessed by the electric safety lamp of giving a large amount of light where a large amount of light would be specially serviceable, is a power not possessed by the oil safety-lamp.

With the oil lamp, safety against explosions has been procured at the cost of diminished light, and no safety lamp exists, except the electric safety-lamp, which will give a good light and be at the same time a safe one.

The smallness of the light of the oil safety-lamp, of the kind least likely to cause explosion, is a large set off against its safety as a whole, when taken in connection with the other risks to life and limb which exist in mines, besides those arising out of the presence of explosive gases.

The two great sources of danger in coal mines, fire-damp and falls of the roof and sides, are both guarded against by the electric lamp; the danger of explosion, by the light being entirely out of contact with the atmosphere of the mine, and danger from falls of the roof and sides, by the better light procurable by means of electricity.

There cannot be a question that the electric lamp, in the form in which it is now presented, possesses these advantages, and that its introduction into mines is merely a question of convenience and cost.

The importance of these considerations, minor though they be, are not for a moment under-estimated, and therefore much thought has been bestowed upon both points, with a view to bring them within practical limits. As far as can be judged from the experimental use of these lamps, they will neither be very troublesome nor very costly in process of use.

The batteries are charged, very simply, as has been explained, by setting them down on a charging bench, to which the current is brought from a small dynamo, and leaving them there while the men are at work. Perhaps once a week a few drops of dilute acid will have to be added to compensate for loss by effervescence during charging. The expense of charging is almost nothing.

Five horse-power would keep 1,000 lamps going—500 on the charging circuit and 500 in use in the mine.

The cost of lamp renewals would be the heaviest charge, and would probably amount to 2d. per lamp per week. Where the number of lamps was considerable, perhaps 1d. or 1½d. would cover the cost per

lamp of wages for keeping the lamps charged and in order. Another 1d., making 4½d. per week, would cover the charge for interest on the capital outlay for first cost of lamps and other plant.

Referring to the fire-damp indicator, which has been made in three forms, two of these act on the same principle as Liveing's fire-damp indicator. A spiral coil of thin platinum wire is arranged so that it can be heated to a low red heat by switching through it the current generated by the lamp battery. If this takes place in an atmosphere in which fire-damp is present, the wire becomes hotter than when heated in pure atmospheric air, because combustion of the fire-damp with the oxygen of the air, brought about by the electrically heated wire, produces additional heat, and, consequently, increases the temperature of the wire, so that it is sensibly brighter when heated in air containing fire-damp, than when heated in air in which there is no fire-damp.

In one form of the indicator, Mr. Liveing's idea of having a comparison wire shut up, air-tight, in a glass tube containing pure air has been followed. In another, Liveing's construction has been deviated from in two ways, namely, by having only one wire (the test wire,) and instead of this being in a wire gauze cage, always exposed to the atmosphere in which the lamp is placed, it is in a tube which, when the current is turned on to heat the wire, is completely closed. It is not easily conceivable, even if the test were made in an atmosphere of air and fire-damp of maximum explosiveness, that flame would pass the four-fold lining of fine copper wire gauze of the Liveing indicator; still it is, perhaps, more consistent with the absolute safety of the lamp itself, to make the test in a closed vessel. With the double wire arrangement, when fire-damp is present in the air, even in so small a proportion as half a per cent., the *exposed* wire glows with perceptibly greater brightness than the *enclosed* comparison wire. With the single wire arrangement, under the same atmospheric conditions, the wire would glow for an instant with extra brightness, and then, after the small quantity of enclosed fire-damp was consumed, would die down to normal redness.

The third form of indicator acts upon a different principle. In it there is a platinum wire *h* within a small tube *c*, with the means of turning on the current from the lamp battery to heat the wire, as before; but here the hot wire is employed only to effect the combustion of any fire-damp that may be present, with a view to the production of a partial vacuum resulting from the condensation of the watery vapour of the burnt gases. The degree of vacuum or shrinkage is shown by the rise of liquid *g'* in an adjacent gauge tube *g'*, and from this the exact percentage

To illustrate Mr. J. Wilson Swan's

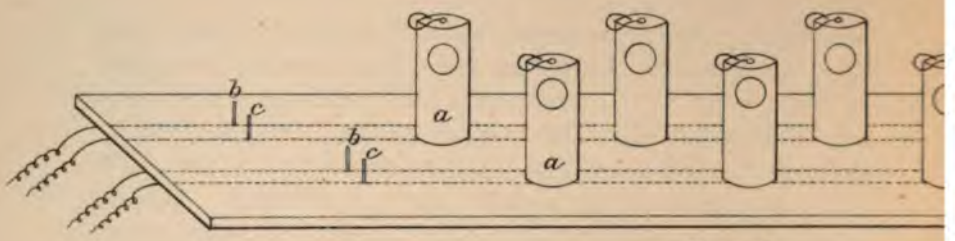


FIG. 5.

FIG. 1.

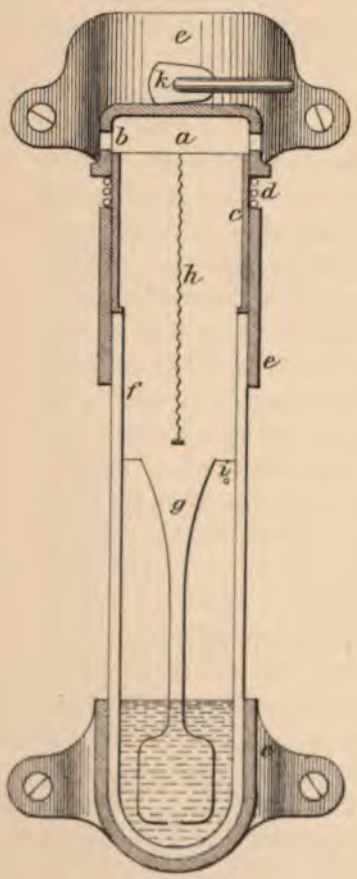
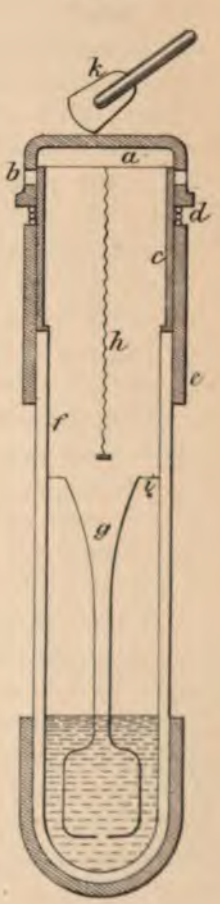


FIG. 2.



Scale

Proceedings N.E. of M. & M.E. 1886-87.

n an improved Electric Safety Lamp."

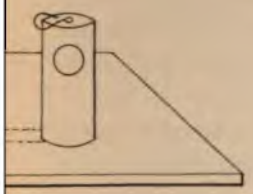


FIG. 4.

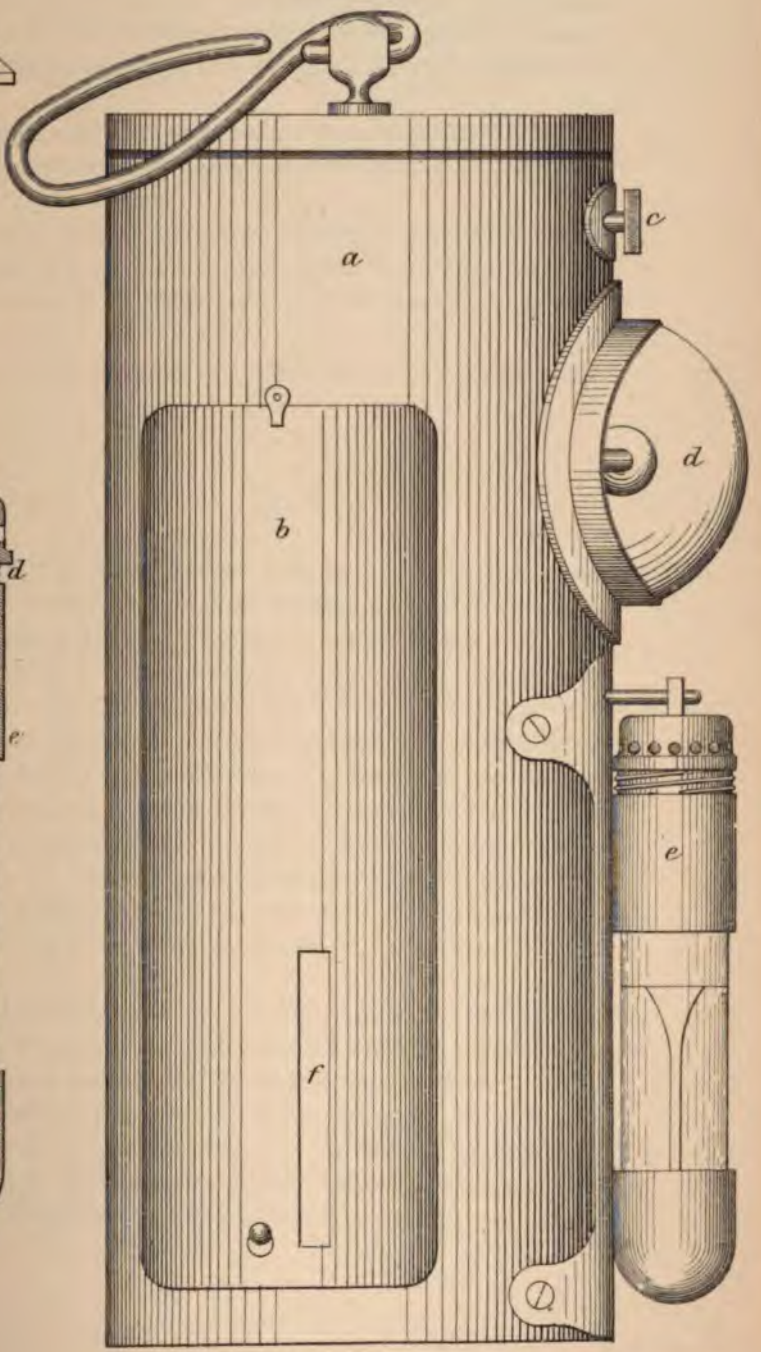
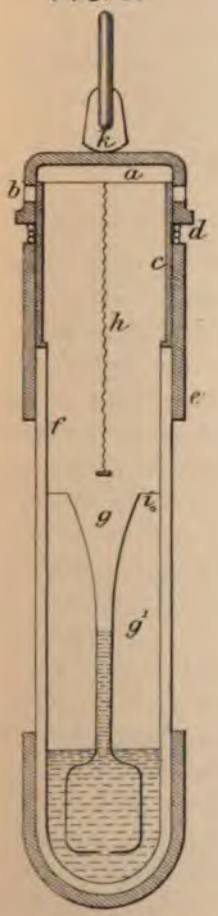


FIG. 3.



Size.

of fire-damp present in the air may be ascertained. This form of test is also, and necessarily, made in a closed vessel. The hot wire is completely cut off from contact with the outer air.

For the simple detection of the presence or absence of fire-damp, the two-wire form is quite efficient down to $\frac{1}{2}$ per cent., but for measurement of the quantity, even down to $\frac{1}{4}$ per cent., the liquid indicator is the more exact.

Both are instantaneous in their action as mere indicators, but for actual measurement from two to five minutes are required for each observation.

The instrument is here shown attached rigidly to the body of a lamp, but it can be made in another form, which allows of the indicator, apart from the lamp, being swept along the roof of the mine when searching for gas.

At the close of the meeting the action of both instruments was demonstrated.

Mr. SWAN, whilst reading the paper, made an experiment showing the action of the gas indicator attached to the lamp, in a mixture of about one per cent. of gas, which, it was explained, was a long way short of an explosive mixture, yet might prove dangerous in the presence of a very fine dry coal-dust. He also explained that it would take a minute or two to complete the experiment, with the imperfect means he had at his command, to effect the complete diffusion of the gas in the vessel used to contain the mixture, and to get it to enter the test cylinder; when in practice, this latter process could be instantly effected by using a little tube by which the air from the mine can be drawn into the test tube by the mouth. The diffusion into the test tube of the air of the mine was, in another form of the same apparatus, effected instantly and without aspiration.

In reply to a question from the President, as to the price of the lamps, Mr. Swan stated that in calculating the expense of keeping the lamps in operation, he had assumed interest at the rate of ten per cent., on a cost of £2 for the lamp without the gas indicator. He could not say, however, how far this assumption might be borne out in actual fact. It may be possible to make lamps for a great deal less, if they come to be used in large numbers, but this is about the cost at present.

In reply to a question by Mr. G. B. Forster, Mr. Swan stated that the presence of gas would be instantly detected; the experiment which is being made at this moment is not only to get an indication of the presence of the gas, because the extra brightness of the wire will do that at once; but to measure the proportion of gas present in the mixture, and this takes time, and can only be done by persons who will take the necessary pains to do it properly.

In reply to Mr. John Daglish, Mr. Swan stated that the lamp with the indicator would be for sale in a short time.

The SECRETARY stated that Mr. Greenwell, who, unfortunately, was unable to be present, had suggested in a letter the propriety of protecting the glass covering the glow light by wire gauze, or by a combination of wire gauze and glass.

Mr. SWAN did not think it would be an advantage to have any further protection for the lamp than the thick glass cap. He did not think it necessary, because, unlike the glass in the Clanny lamp, or any other form of miners' oil lamp, the glass in the electric lamp did not become much heated, and therefore, there was not the same danger of the glass being cracked by drops of water falling upon it, as existed in the case of the glass in miners' lamps of the ordinary form. There was hardly any limit to the thickness which they could give to the glass cap. Glass was really a very strong material if made thick. He believed the chances of the protecting cap being broken were exceedingly remote—so remote as to make it not necessary to provide any additional protection.

The PRESIDENT—One or two strong wires would be sufficient protection, without interfering with the light.

Mr. G. B. FORSTER—Any interruption by wires would absorb a good deal of the light, and he doubted whether two or three bars would do any good. He thought if a mere ordinary blow were given to the glass shown, it would be strong enough to receive it.

The SECRETARY—Mr. Greenwell, in a second letter, adds, that there are other causes besides concussion which produce sudden fracture of the glass; besides the glass might be chipped at the edges, or be so loosely screwed on over the glow glass that gas might be constantly between it and the light, and ready to explode if the glow glass were broken; and in order to show the peculiar danger inherent in glass protectors, he referred to Vol. XVIII., part 19, of the "Transactions of the Manchester Geological Society," where, in a paper by Mr. Henry Hall, one of Her Majesty's Inspectors of Mines, it was stated that out of 24,334 Mueseler lamps with Smethurst shields, 88 had to be taken out

and replaced between February 1st and March the 20th inclusive, 40 of which were either completely broken, or in a condition to render them unsafe to continue their use, and the remaining 48 were snipped partly across the edges, but not so as to render them actually unsafe.

Mr. BLACKETT—In the ordinary use of this lamp, how will it be possible to tell when there is danger of stythe?

Mr. SWAN admitted that this lamp afforded no indication of the presence of stythe, neither would the old-fashioned lamp give one.

Mr. G. B. FORSTER—The present lamp goes out before life is in danger.

Mr. SWAN asked whether "stythe" was carbonic acid or carbonic oxide?

Mr. DAGLISH—Carbonic oxide.

The PRESIDENT said he had never heard of carbonic oxide in pits.

Mr. G. B. FORSTER—In the case of the Hartley accident carbonic oxide killed the men, but it was supposed to have come from the fire of the ventilating furnace.

The SECRETARY observed that Mr. Walker, of Cardiff, who unfortunately was unable to be present, stated in a letter that he had been experimenting with an electric lamp, using a primary battery, which had given very excellent results. It weighed 4½ lbs., and was capable of furnishing a light of 5 candles for 10 hours, leaving sufficient energy in the battery to give a smaller light for other 2 hours. The case held 4 zinc carbon cells, and the process of charging consisted simply in putting in the acids and screwing on the top, changing the zinc plates when required. The estimated cost of maintenance for zinc and acids, including the necessary attendance, was 1d. per shift of 12 hours as described, which it is presumed would favourably compare with the present cost of keeping lamps in order. Since experimenting on this lamp, the writer had succeeded in still reducing the size and weight of the lamp, and he hoped by the next meeting to be able to present to the Institute an improved lamp on this principle, which does not weigh more than 3 lbs., is 6 inches high, and 3 inches in diameter (not including the glow lamp itself and its protecting glass), and furnishing a light of 3 candles for 10 hours, and 2 candles for a further 2 hours. From experiments, carried out under his own eye, the writer assumes that the working expense will be reduced to under ½d. a day. It will be seen that the chief difference between Mr. Swan's lamp and the one now mentioned is that Mr. Swan works with a secondary battery while Mr. Walker works with a primary one; the one necessitating the use of an engine and dynamo, which must always be available for charging, while

the other can be used in any position in any case of emergency, besides possessing the very great advantage of being nearly one-half the weight of the secondary battery. The writer promises to send one over as soon as he has it ready.

Mr. SWAN stated, in answer to questions from various members, that his lamp weighed $5\frac{3}{4}$ lbs. That with 1 per cent. of gas the red fluid would rise to the full height, indicating the amount in about 2 minutes, and the heat of the mine would make no difference as to this, as the whole machine would have acquired the same temperature as the air in the mine: with 2 or 3 per cent., or when an explosive point was reached, the gauge would act instantly. He thought it was, perhaps, not fair for him to anticipate the reading of Mr. Walker's paper, except that he wished really to help on the object they all had in view, and enable them to form a just estimate of what was of real value to them, and what was not. It was only this excuse he could plead in suggesting that any primary battery, so far as he could conceive of it, would be found, without considering at all the cost of the metal, and the acid used in it, far too troublesome to keep in operation for any practical service. Where they had to deal with hundreds of lamps, to be charged every day, the filling of them with fresh acid, and the replacing of the worn out zinc—for it would become worn out, and would have to be frequently renewed—would involve an amount of labour far in excess of any other cost in connection with the lamp.

The PRESIDENT said, that whatever might come of any further discovery in connection with the lamp, he was sure they would all feel greatly indebted to Mr. Swan, not only for being one of the earliest gentlemen in the field in connection with this subject, but also for giving himself the trouble of coming there to exhibit and explain the lamp. He proposed a vote of thanks to Mr. Swan.

Mr. G. B. FORSTER said, he had much pleasure in seconding the vote of thanks. He thought this was one of the most interesting experiments which had ever been before the Institute; and, although they might not see their way yet to introduce this lamp, he hoped the time would soon come when it would be put into such a form that it would be introduced generally. What they had to particularly pay attention to in mines was the detection of gas. They could not put this lamp into the hands of men in fiery mines, without having some means of knowing when gas was there.

The resolution was agreed to.

Mr. SWAN said, he was much obliged to them for the vote of thanks which they had been good enough to tender him. He must be allowed

to take the opportunity of saying that he thought the last words of Mr. Forster were really completely met, either by Liveing's form of fire-damp indicator, so far as fire was concerned, or by the third form of indicator, which he had not been able to show in as demonstrative a fashion as he should have liked, owing to the fact that the arrangement that he had present was an extemporised one, not favourable at all to show the action of the indicator. He thought that the deficiency of the lamp to indicate the presence of stythe might be easily overcome.

Mr. W. H. Wood—Suppose it was a hot mine ?

Mr. Swan—That would not make any difference, because the whole apparatus would be in the same temperature.

Mr. Wood—Said that he understood that the apparatus had to cool before the liquid would rise.

Mr. Swan—Yes ; but it only has to get down to the initial temperature, whatever that may be. If there were 2 or 3 per cent. of gas it would act instantly.

The President—If it got to an explosive point it would act instantly ?

Mr. Swan—Yes.

Mr. Wood—What is the illuminating power of that lamp ?

Mr. Swan—1½ candles to begin with, and ending with 1 candle.

Professor J. H. Merivale read the following paper "On Further Experiments on the Transmission of Power by Steam :"—

TRANSMISSION OF POWER BY STEAM.

By Professor J. H. MERIVALE, M.A.

A paper by Messrs. Liddell and Merivale upon this subject was read at the April meeting of the Institute, and published in Vol. XXXV., p. 159, of the Transactions. Since that date the steam at Broomhill Colliery has been carried in a further distance of 120 yards, making a total of 1,414 yards from the boiler at bank to the in-bye engine. Preparations are now being made to shift this engine to its final position near the boundary of the royalty, a further distance of some 40 yards, which will make the grand total about 1,450 yards between engine and boiler.

The range is now in three sections, viz.:—1. From the boilers to the A engine, 342 yards of 5 inch steam pipes (described in the author's former paper). 2. From the A to the B engine, 952 yards of 2½ inch steam pipes (described in the former paper). 3. From the B to the C engine, 120 yards of 1¼ inch steam pipes. Total distance from the boiler at bank to this engine, 1,414 yards. The C engine is a little donkey pump, 3 inches diameter by 10 inches stroke, with steam cylinder 6 inches diameter by 10 inches stroke; it runs 5½ hours out of the 24, at 60 revolutions, and the steam pipe is covered with Wormald's composition.

The larger of the two boilers already described supplies the three engines running simultaneously without much difficulty, so that the installation is now laid off at night. The boiler evaporates 273 gallons of water per hour, at 56 degs., into steam of 35 lbs. pressure, with a consumption of 427 lbs. of rough small coal. Of these 273 gallons, 57½ (or 21·06 per cent.) are collected at the steam traps, *i.e.*, are lost by condensation and priming. With larger pipes the percentage of loss would, of course, have been less.

The author has made numerous experiments upon this range of pipes, and has been in correspondence with Mr. Charles E. Emery, manager and engineer of the New York Steam Company, where several miles of pipes

are in operation, supplying power and heat to many of the factories and houses in that city. He has also, through the kindness of Mr. Henry Palmer, been able to make an experiment upon the steam pipes at East Howle Colliery. From the information thus obtained, the author has attempted to draw up some formulæ and tables, which he thinks may be of value in the design of similar installations.

The special problems that the mining engineer has to solve in a steam transmission are these:—How many cubic feet of water must be evaporated at bank, and at what pressure, to supply the required power at a known distance from the boiler? What must be the size of the pipes through which the steam is to be conveyed, and the character and thickness of their non-conducting envelope? What precautions must be adopted to provide for expansion and contraction of the steam pipes, and the collection of the water of condensation?

The quantity of water to be evaporated at bank depends upon the amount of condensation in the pipes. This matter has been investigated by Dulong, and is now well understood. Box, in his "Practical Treatise on Heat" (page 226, third edition), gives Dulong's rules, and some tables calculated from them. These tables, however, intended for calculations relating more to the heating of buildings than to the transmission of power, are not quite suited to the question, and the author has extended them, at the same time giving Dulong's formulæ for use where great accuracy is required.

The loss of heat, and consequent condensation, is due to two causes—radiation and contact with air.

Loss by Radiation.

Let U = units of heat lost by radiation per hour.
S = surface of covered pipe in square feet.
D = difference of temperature in degs. Fahrenheit between surface of covered pipe and drift or shaft sides.
R = (see Table I.)

Then—

(1.) $U = 0{\cdot}74DSR.$

Let L = lbs. of steam condensed per hour.
H = latent heat of steam (see Table II.) at the mean pressure in the pipe.

Then—

(2.) $L = \frac{U}{H}.$

TABLE I.

The ratio of heat emitted or absorbed at different temperatures.

Let R = ratio of loss of heat.

t = cent. temperature drift sides.

T = cent. difference of temperature between pipe surface and drift sides.

Then—

$$(3.) \qquad R = \frac{124{\cdot}72 \times 1{\cdot}0077^{t} \times (1{\cdot}0077^{T} - 1)}{T}.$$

Reduced to Fahrenheit's scale this formula gives the following, Table I.:—

T.	t.							
,	59°	63½°	68°	72½°	80°	86°	91°	95°
	R.	R.	R.	R.	R.	R.	R.	R.
Degs.								
18	1 120	1·14	1·165	1·178	1·223	1·254	1·271	1·300
27	1·14	1·159	1·185	1·190	1·247	1·276	1·305	1·327
36	1·1	1·177	1·206	1·202	1·272	1·299	1·330	1·352
45	1·18	1·20	1·229	1·231	1·297	1·323	1·357	1·381
54	1·20	1·23	1·251	1·261	1·323	1·348	1·385	1·406
63	1·225	1·25	1·276	1·289	1·350	1·375	1·407	1·435
72	1·25	1·283	1·302	1·317	1·377	1·403	1·429	1·464

TABLE II.

SHOWING PRESSURE, TEMPERATURE, WEIGHT, VOLUME, TOTAL HEAT, AND LATENT HEAT OF SATURATED STEAM.

Total Pressure. Lbs.	Temperature. Fah.	Weight in Ozs. per Cubic Foot.	Volume compared with Volume of Water that has produced it.	Total Units of Heat per Lb. from 32°.	Latent Heat per Lb
10	194	0·4208	2,375	1,141	979
11	198	0·4608	2,167	1,143	976
12	202	0·5008	1,994	1,144	973
13	206	0·5408	1,846	1,145	971
14	210	0·5808	1,720	1,146	968
15	213	0·6208	1,609	1,147	965
16	217	0·6608	1,512	1,148	963
17	220	0·7008	1,427	1,149	961
18	223	0·7408	1,350	1,150	959
19	226	0·7792	1,282	1,151	958
20	228	0·8192	1,220	1,152	956
21	231	0·8576	1,165	1,153	953
22	234	0·8976	1,113	1,153·5	951
23	236	0·9376	1,067	1,154	950
24	238	0·9760	1,024	1,155	948

TABLE II.—*Continued.*

Total Pressure. Lbs.	Temperature. Fah.	Weight in Ozs. per Cubic Foot.	Volume Compared with Volume of Water that has produced it.	Total Units of Heat per Lb. from 32°.	Latent Heat per Lb.
25	240	1·0144	985	1,156	946
26	243	1·0544	948	1,156·5	945
27	245	1·0928	915	1,157	943
28	247	1·1312	883	1,157·5	942
29	249	1·1696	854	1,158	940
30	251	1·2080	827	1,159	939
31	253	1·248	801	1,159·5	938
32	254	1·286	767	1,160	936
33	256	1·325	755	1,160·5	935
34	258	1·360	734	1,161	934
35	260	1·400	714	1,161·5	933
36	261	1·438	695	1,162	931
37	263	1·477	677	1,162·5	930
38	264	1·515	660	1,163	929
39	266	1·553	644	1,163·5	928
40	268	1·590	628	1,164	927
41	269	1·628	614	1,164·5	926
42	271	1·665	600	1,165	925
43	272	1·704	587	1,165·5	924
44	273	1·741	574	1,166	923
45	275	1·779	562	1,166·5	922
46	276	1·816	551	1,166·8	921
47	277	1·853	539	1,167	920
48	279	1·891	529	1,167·5	919
49	280	1·928	519	1,167·8	918
50	281	1·965	509	1,168	917
51	283	2·001	499	1,168·5	916
52	284	2·038	490	1,168·8	915
53	285	2·075	482	1,169	914
54	286	2·112	473	1,169·5	913
55	287	2·149	465	1,169·8	912
56	288	2·185	457	1,170	911·5
57	290	2·222	450	1,170·5	911
58	291	2·259	443	1,170·8	910·5
59	292	2·294	436	1,171	910
60	293	2·331	429	1,171·5	909·5
65	298	2·512	398	1,173	906
70	303	2·689	372	1,174·8	901
75	308	2·867	349	1,176·5	898
80	312	3·043	329	1,177·8	895
85	316	3·217	311	1,179·2	891
90	320	3·390	295	1,180·5	888
95	324	3·560	281	1,181·5	885·7
100	328	3·728	268	1,182·5	883·7

Loss by Contact with Air.

This will be greater with horizontal than with vertical pipes.

Horizontal Pipes.

Let U_1 = units of heat lost per hour by a horizontal pipe from contact with air.

S = surface of covered pipe in square feet.

R_1 = (see Table III.)

D_1 = difference of temperature in degrees Fahrenheit between surface of covered pipe and the air.

A = (see Table IV.)

Then—

(4.) $$U_1 = D_1 R_1 A S,$$

And the lbs. of steam condensed can be found from (2).

TABLE III.

The ratio of heat emitted or absorbed by contact with air with given differences of temperature.

Let R_1 = ratio of loss of heat.

t = difference of temperature of the pipe surface and the air in degrees cent.

Then—

(5.) $$R_1 = \frac{0{\cdot}552 \times t^{1{\cdot}233}}{t}.$$

Reduced to Fahrenheit's scale, this formula gives the following, Table III., of values of R_1 :—

t.	R_1.	t.	R_1.	t.	R_1.
Degrees.		Degrees.		Degrees.	
9	0·782	45	1·168	72	1·305
18	0·943	54	1·219	81	1·341
27	1·037	63	1·263	90	1·372
36	1·109				

TABLE IV.

If r = radius of horizontal covered pipe in inches.

(6.) $$A = 0{\cdot}421 + \frac{0{\cdot}307}{r}.$$

r.	A.	r.	A.	r.	A.	r.	A.
2	0·5745	3¼	0·5154	4½	0·4892	6½	0·4682
2¼	0·5574	3½	0·5087	4¾	0·4856	7	0·4648
2½	0·5440	3¾	0·5028	5	0·4824	7½	0·4619
2¾	0·5326	4	0·4978	5½	0·4768	8	0·4593
3	0·5230	4¼	0·4930	6	0·4722	9	0·4551

Vertical Pipes.

Let U_{11} = units of heat lost per hour by a vertical pipe from contact with air.

A_1 = (see Table V.)

S, R_1, and D_1 as in (4).

Then—

(7.) $U_{11} = D_1 R_1 A_1 S$,

And the lbs. of steam condensed can be found from (2).

TABLE V.

If r = radius of vertical covered pipe in inches.

h = height of vertical pipe in inches.

Then :—

$$(8.)\ A_1 = \left\{ \cdot 726 + \frac{\cdot 2163}{\sqrt{r}} \right) \times \left(2 \cdot 43 + \frac{5 \cdot 49}{\sqrt{h}} \right\} \times \cdot 2044.$$

This formula gives the following Table V., taking A_1 in feet.

Radius in Inches.	Height of Pipe in Feet.			
	50	100	200	300
r	A_1.	A_1.	A_1.	A_1.
2	0·4769	0·4650	0·4571	0·4534
2½	0·4676	0·4560	0·4478	0·4442
3	0·4614	0·4500	0·4419	0·4384
3½	0·4562	0·4448	0·4368	0·4333
4	0·4526	0·4412	0·4333	0·4299
4½	0·4491	0·4378	0·4300	0·4266
5	0·4462	0·4352	0·4273	0·4239
5½	0·4437	0·4328	0·4250	0·4216
6	0·4416	0·4298	0·4220	0·4186
6½	0·4398	0·4289	0·4212	0·4178
7	0·4380	0·4272	0·4196	0·4162
7½	0·4366	0·4257	0·4181	0·4147
8	0·4352	0·4244	0·4168	0·4134
9	0·4330	0·4220	0·4146	0·4112

By means of the above formulæ and tables, the quantity of steam that will be condensed (that is to say, the quantity of steam that must be produced by the boiler in addition to that required to drive the engine)

in the range of pipes can be easily calculated if only the surface temperature of the pipes, of the air, and drift sides be known. How these may be obtained will be presently pointed out.

Loss by Friction.

The laws governing the resistance that fluids meet with in passing through iron pipes (and other conduits also; which, however, it is not necessary to consider now) do not appear to be thoroughly understood. M. Stockalper found, from experiments upon the flow of compressed air through pipes made at the Mont Cenis tunnel, and published in the *Revue Universelle des Mines*, Sér. 2, Vol. VII., p. 257, that Darcy's formula for the flow of water through iron pipes, reduced in the ratio of the density of air to that of water, gave satisfactory results. Mr. Emery, too, in a lecture on the transmission of steam, published in the *Scientific American* of 29th May, 1886, says:—"Considerable investigation was made to ascertain the proper formulæ for determining the size of pipes required to transmit the steam. The difficulty was not so much in finding formulæ, as to decide which were best applicable. As is generally the case, the simplest was finally determined upon, based directly upon the laws of falling bodies, and in form that generally used for the *flow of water in pipes*, simply substituting for the density of water that of steam at the pressure to be carried."

Acting upon these suggestions, the author has made use of Darcy's formula for the flow of water, after having converted it into British units, as follows:—

Let P = boiler pressure in lbs. per square inch.
p = pressure required at engine in lbs. per square inch.
l = length of pipe in yards.
d = weight of 1 cubic foot of the fluid in oz. (for steam, see Table II.)
D = diameter of pipe in inches.
Q = cubic feet of the fluid passing per second.
a = see (Table VI.)

Then—

$P - p$ = loss of pressure between boiler and engine;

And—

$$(9.)\quad P - p = \frac{laQ^2d}{1{,}000{,}000}.$$

$$(10.)\quad Q = \sqrt[2]{\frac{1{,}000{,}000\,(P-p)}{lad}}.$$

$$(11.)\quad a = \frac{1{,}000{,}000\,(P-p)}{lQ^2d}.$$

TABLE VI.

VALUES OF *a* FOR DIFFERENT INTERNAL DIAMETERS D, OF PIPES IN INCHES.

(12.) $$a = \frac{306{,}703{,}494\ b}{D^5};\ \text{and}$$

(13.) $$b = \cdot 000507 + \frac{\cdot 00050946}{D}.$$

Internal Diameter of Pipe in inches.	*a*.	Internal Diameter of Pipe in inches.	*a*.
1¼	91,960	5½	36·54
2	7,302	6	23·29
2½	2,232	6½	15·47
3	812	7	10·58
3½	381	8	5·34
4	190	9	2·927
4½	103·7	10	1·717
5	59·7	11	0·9872

EXPERIMENTS UPON THE LOSS DUE TO CONDENSATION.

Though Dulong's formulæ are not the results of theoretical calculations, but of practical experience, the members of the Institute will perhaps have more confidence in their value for mining purposes if they will compare them with the results obtained by actual measurements in the mine.

Taking the 952 yards of 2½ inch wrought iron pipes at Broomhill Colliery, for an example, and :—

LOSS BY RADIATION.—FORMULA (1).

$D = 120° - 72° = 48°.$

$S = 952 \times 3 \times 1{\cdot}63 = 4{,}655.$

$R = 1{\cdot}231.$

Then—

$U = 0{\cdot}74 \times 48 \times 4{,}655 \times 1{\cdot}231 = 203{,}540.$

LOSS BY CONTACT WITH AIR.—FORMULA (4).

$D_1 = 120° - 77 = 43°.$

$R_1 = 1{\cdot}155.$

$A = 0{\cdot}523.$

Then—

$U = 43 \times 1{\cdot}155 \times {\cdot}523 \times 4{,}655 = 120{,}909.$

And—

$U + U_1 = 324{,}449$ units of heat,

And the mean pressure of the steam being about 36 lbs. above the atmosphere the latent heat by Table II. is 916, and the lbs. of condensed water produced will be by formula (2),

$$L = \frac{324{,}449}{916} = 354{\cdot}1 \text{ lbs. per hour,}$$

and this is equal to 35·41 gallons.

The average of four measurements of the water of condensation delivered at the steam traps gave 38·83 gallons per hour. The quantity delivered by the traps should be slightly greater than the quantity obtained by calculation, because there is a small additional condensation due to naked expansion joints, and damaged places in the non-conducting covering, which is not allowed for in the formulæ.

An experiment upon the 5 inch pipes from the bottom of the shaft to the A engine, 269 yards, gives—

Loss by Radiation.—Formula (1).

$D = 120 - 74 = 46°.$

$S = 2{\cdot}62 \times 3 \times 269 = 2{,}114{\cdot}34.$

$R = 1{\cdot}24.$

Then—

$U = 0{\cdot}74 \times 46 \times 2{,}114 \times 1{\cdot}24 = 89{,}231.$

Loss by Contact with Air.—Formula (4).

$D_1 = 120° - 79° = 41°.$

$R_1 = 1{\cdot}138.$

$A = {\cdot}4824.$

Then—

$U_1 = 41 \times 1{\cdot}138 \times {\cdot}4824 \times 2{,}114 = 47{,}604.$

And—

$U + U_1 = 136{,}835$ units of heat;

and the mean pressure of the steam being about 40 lbs. above the atmosphere the latent heat by Table II. is 912. The condensed water therefore will be by Formula (2)—

$$L = \frac{136{,}835}{912} = 150 \text{ lbs. per hour} = 15 \text{ gallons.}$$

The average of two measurements gave 17 gallons of water of condensation per hour. So that, as in the case of the $2\frac{1}{2}$ inch pipes, the measured quantity is, as it should be, greater than the calculated quantity.

At East Howle Colliery, however, the quantity got by calculation was rather more than that obtained by actual measurement, viz., 44¼ gallons per hour, as against a measured condensation of 42 gallons. The portion of the range experimented upon is 885 yards in length, and is carried through rather a small return airway. The temperatures were only taken at two places; and these, being near a separation door, gave probably a difference of temperature rather more than the average of the range. This may account for the calculated condensation being rather more than the measured condensation, instead of being rather less, as the author would have been inclined to expect.

The author considers these experiments prove that Dulong's formulæ, which would undoubtedly give accurate results if accurate measurements could be taken, give results near enough for practical purposes with such rough measurements as can be made in a mine.

Experiments upon the Loss due to Friction.

The author found some difficulty in making satisfactory experiments upon this point, because of the impossibility of knowing exactly the quantity of steam passing through the pipes; and as the loss of pressure due to friction varies as the quantity squared, a small error in the quantity would give a large error in the loss of pressure.

The volume of steam passing is composed of—

1. The volume generated by the piston before the point at which the steam is cut off.
2. The quantity of steam condensed in the pipes; which is a maximum at the boiler end, and nothing at the engine end.
3. The quantity lost through leakage from pipes and cylinder.

1.—Volume generated by piston. In order to obtain this quantity, the steam valve was opened full and the number of revolutions, which were regulated by means of a brake, counted. The capacity of the cylinder up to the point of cut off, multiplied by the number of revolutions obtained in this way, was taken as the volume of steam passing through the pipes due to the engine.

2.—The total volume due to condensation was found by measuring the condensed water, and calculating from it the volume of steam; and it was assumed, as will be practically the case, that in a pipe of uniform section, with no very great variation in temperature, the condensation takes place uniformly from end to end.

3.—The leakage it is impossible to estimate, and it was therefore neglected.

If V = volume of steam in cubic feet per second produced by the boiler.

v = volume of steam in cubic feet per second consumed by the engine.

Q = mean volume in cubic feet per second passing through the pipe.

Then, assuming that $V - v$ is the volume of steam lost by condensation; that is to say, neglecting leakage—

$$(14.) \qquad Q^2 = \frac{V^2 + Vv + v^2}{3},$$

and formula (9), becomes—

$$(15.) \qquad P - p = \frac{lad}{1{,}000{,}000} \times \frac{V^2 + Vv + v^2}{3}.$$

Testing this formula upon the range of 952 yards of 2½ inch pipes supplying the B engine, the author got the following result, the engine making 80 revolutions:—

P (pressure at out-bye end of range) = 41 lbs.

p (do. at B engine) = 33½ lbs.

l = 952 yards.

d = 2·07 (Table II.)

a = 2,232 (Table VI.)

v = 0·700 (the volume of the cylinder, with cut off at one-fourth, is 0·5235 cubic feet per revolution).

V = 1·553 (there are 39½ gallons of water of condensation produced per hour).

Then by experiment—

$$P - p = 41 - 33{\cdot}5 = 7\tfrac{1}{2} \text{ lbs.}$$

By calculation, formula (15)—

$$P - p = \frac{952 \times 2{,}232 \times 2{\cdot}07}{1{,}000{,}000} \times \frac{(1{\cdot}553)^2 + (1{\cdot}553 \times {\cdot}7) + {\cdot}7^2}{3},$$

$$= 2{\cdot}125 \times 2{\cdot}07 \times 1{\cdot}33 = 5{\cdot}85 \text{ lbs.},$$

or 1·65 lbs. less than the actual loss.

This is not quite correct; but the loss by calculation should be less than the loss by experiment, because in the calculation no allowance is made for leakage, and the author considers, therefore, that Darcy's formula for the flow of water through pipes may be conveniently applied to the flow of steam.

The Design of a Steam Transmission.

The only difficulty that can arise in making use of these formulæ for the purpose of determining the size of pipes and boiler power required for any proposed transmission, lies in the estimation of the surface temperature of the covered pipe. This will depend upon the composition used, and its thickness; and upon the temperatures of the steam, the air, and drift sides. As it is independent of the diameter and length of the pipe, the simplest plan is to make an experiment by covering three or four yards of pipe with the composition to be used. Or reference may be made to a very valuable series of experiments upon various non-conducting compositions, carried out by Mr. Bird, Assoc. Sc., and read before this Institute. See Vols. XXIX., XXXI., and XXXII.

The following, Table VII., shows the results of some experiments made by the author with Wormald's composition. It will be noted that the differences of temperature do not vary much:—

TABLE VII.

Experiments with Wormald's Composition.

Thickness of Composition.	Approximate Temperature of the Steam.	Temperature of Surface of Covered Pipe.	Temperature of the Air.	Difference of Columns 3 and 4.	Temperature of Drift Sides.
Inches.	Degrees.	Degrees.	Degrees.	Degrees.	Degrees.
1⅛	281	122	77	45	72
1¼	275	101	62	39	62
1⅜	275	100	62	38	62
1 1/16	281	121	77	44	72
1 1/16	271	120	77	43	72
1 1/16	285	120	79	41	74
1¾	287	132½	91	41½	89
1⅞	287	132	94	38	93½
1⅞	287	109	77	32	open air.
1⅞	286	107	76	31	do.
2⅛	287	107	77	30	do.
2¼	286	104	76	28	do.

Having determined the temperatures in one or other of these ways, the steam required to supply the condensation can be readily obtained from formulæ (1) to (7). Experience seems to show that a little under 10 per cent. must be added to this for condensation at the steam traps and expansion joints.

The volume required for the engine is of course known, and this (the engine volume) added to the condensation volume gives the gross quantity to be supplied by the boiler, and consequently the boiler power required.

The mean volume squared passing through the pipe is got from the engine volume and condensation volume by formula (14), and finally the size of the pipes from formula (11).

Practical Details.

Provision must be made for carrying off the water of condensation, and for expansion of the steam pipes. The first is well understood, and the author would only suggest that a trap be placed as near the boiler as possible, to intercept the water carried over by priming. It was found at Broomhill that whereas the trap next the boiler gave a gallon per 7·3 yards of pipe, the second trap from the boiler gave a gallon per 15·8 yards.

For the low pressures usually adopted at collieries (say not more than 45 lbs. above the atmosphere) the ordinary stuffing-box expansion joint answers admirably; but with higher pressures there is considerable difficulty. The New York Steam Company (pressure 80 lbs.) have made a great many experiments upon expansion joints, and finally settled upon a modification of the diaphragm joint. It is made of discs of copper 0·04 inches thick, corrugated concentrically, and supported on radial backing plates, which prevent the diaphragm from being distended to rupture by the pressure.

Provision must be made for dealing with the exhaust steam. If the engine is used for pumping, and there be sufficient water, the simplest plan is to turn the exhaust direct into the suction pipe. By this means not only is the steam killed but a vacuum is obtained, and the engine made more efficient. At East Howle Colliery, instead of turning the exhaust direct into the suction, they carry the exhaust pipe some thirty yards inside the rising main, and then turn it into the suction pipe. By this means they consider that they get a more perfect condensation than if the exhaust steam were turned direct into the suction; and they certainly pass cold water through the pump instead of hot, which is an undoubted advantage. At some collieries the exhaust steam is turned into the return. This was for many years the case at Netherton, where it did irreparable damage by getting into the roof and sides, and causing endless expense for timbering. It is also done at Blenkinsopp without, however, much ill result; but there the drift is arched for fifty yards

next the engine. On the whole, the author is of opinion that such an arrangement is unadvisable, and steam should not be taken in-bye if the exhaust cannot be condensed.

Useful Effect.

The discussion that followed the reading of the first part of this paper showed that there was an impression amongst many of the members that transmission by steam to long distances (1,200 or 1,500 yards) was not economical. If by this it is merely meant that, with the small quantities of power usually conveyed in mines, there will be a loss in transmission of 30 or 40 per cent., the author concurs with their opinion; but if it is meant that transmission by steam will not compare satisfactorily with the alternative systems — ropes or compressed air — under similar conditions, the author must differ from these gentlemen.

The useful effect must evidently depend upon the size of the pipe, the nature of the non-conducting material, and the care with which it is kept in repair. At Broomhill, with small pipes, for the most part only 2½ inches in diameter, and where economy in labour is of more importance than economy in the consumption of fuel, the loss due to condensation is 21 per cent., and the loss of pressure about 1 lb. per 100 yards. At New York, with five miles of large pipes, 6 to 16 inches in diameter, and two miles of small ones, 3 inches in diameter, only 450 gallons of water of condensation are formed per hour, equal (the author gathers from Mr. Emery's lecture, already referred to) to a loss of only 2 to 3 per cent.; and the loss of pressure, when the pipes are working to their full capacity, is expected to be 10 lbs. per half mile; at present it is very much less than this.

A great economy, say 50 per cent., would of course be effected if the pipes were covered with polished metal, as is now being done in the case of cylinder covers, and might pay where coal is dear.

A carefully designed rope transmission, in which the driving and driven wheels are 12 to 15 feet in diameter, the intermediate sheaves 6 feet, and the speed of the rope 50 to 60 miles an hour—such an installation, for example, as may be seen at Bellegarde, on the Rhone—is probably the most economical method of transmitting power at present known. But such a system as this cannot be adopted in a mine. The most convenient method below ground is to make use of the main-and-tail rope already in place for hauling. A reference to the report of the Main-and-tail Rope Committee will show that it takes 45 per cent. of the indicated horse-power of the engine to drive the ropes a distance of about 2,000 yards.

A great deal of pumping is done in this way at Broomhill, and experiments made in the Horsley district give the following results :—

Distance from engine to pump, 3,518 yards.	
Power to drive engine	5·74
Power to drive ropes	55·17
Power to drive pump	39·09
Total indicated horse-power	100·00

Water actually pumped, 220 gallons per minute, 76·75 feet vertically, and 1,012 yards horizontally.

The author has not made any experiments with a compressed air transmission ; but he believes the efficiency of the *best* compressors to be about 80 per cent., and the efficiency of the *best* compressed air engines about 70 per cent. That is to say, the maximum efficiency obtained in practice is 56 per cent., excluding loss in transmission by friction from the compressor to the compressed air engine. This is comparable with, but more than, the 20 to 30 per cent. lost by condensation in an *ordinary* colliery steam transmission, and much more than the loss in the *best* steam transmissions.

The loss through friction in the pipe will be greater with air than with steam in the ratio of the density of the air to the density of the steam ; and a given volume of steam at a given pressure will do more work than the same volume of air at the same pressure.

The author does not deny that steam pipes in a pit are more or less of a nuisance, whereas ropes are harmless, and compressed air is a positive blessing. All that he is prepared to maintain is this, that in all cases that are likely to occur in mines, steam, for a distance of 1,200 or 1,500 yards, is as economical as ropes or compressed air, and in some special cases it will be found more economical.

Mr. LAWRENCE said, he did not know that he had very much to say upon this matter. He thought the author had brought before the Institute a large number of statistics, and had given very valuable data, which must have been obtained at a large expenditure of time and trouble to him. He (Mr. Lawrence) contended that there were dangers in carrying steam in pipes underground which they had not in other methods of transmitting power. There was a danger in connection with steam-pipes in a mine, especially of being broken by falls from the roof.

There was also the danger of having split pipes, as they knew from experience, they had to contend with in long lengths of pipe, even connected with ordinary machinery. If they had a pipe split underground, either by a fall from the roof or by an ordinary accident, as they frequently had, it would be a source of danger. Again, another objection to the transmission of steam a long distance was the amount of heat communicated to a mine. As to burst pipes, he had had some experience in this, both in engine-houses and in underground workings. There was the great danger when a split pipe occurred of the whole place being filled with steam, and it was positively so confounding that men did not know what they were about, and had probably to go 150 yards to get to a valve to shut the steam off. This was a source of danger. Where steam was transmitted a long way, as was the case at Broomhill, he would advise that there should be a series of shut-off valves not very far apart. If there was a split pipe 100 yards from the engine, and there was a shut-off valve only at the engine or the bottom of the shaft, a man would have to travel a long way to shut off the steam. He would like to know from Professor Merivale how far a man would have to go to shut off the steam in the case of a split pipe? This was a very essential point. A series of shut-off valves which could be worked from the bank by the man who had charge of the engine, so that he could work them all simultaneously, would remove, to a great extent, the danger which existed.

Mr. MICHAEL DODD thought Mr. Lawrence had entirely overlooked one point. He (Mr. Dodd) had had a little experience in conveying steam underground for the purpose of driving a special pump at the dip workings, a distance of 400 or 500 yards. The steam was conveyed along the way the coals were brought. He remembered distinctly that after the steam had been in for a time there used to be small falls from the roof, bit by bit; to use the word of the pitmen, the stone began to "fleeter" away. A piece from the roof fell in front of a sett on the engine plane, and the sett was thrown off, the timber was brought down, and a heavy fall brought down the pipes, which was a danger Mr. Lawrence had referred to.

Mr. G. B. FORSTER—The danger from falls would be got over in the same way as with water-pipes, by burying the steam-pipes sufficiently deep to prevent falls affecting them.

Professor MERIVALE said, the remarks of the gentlemen who had spoken seemed to credit him with being fond of steam in pits. There was nothing he disliked more. At Netherton, where steam was taken in

a long distance and exhausted direct into the return, his brother-in-law nearly lost his life through the heated atmosphere. All he had attempted to do in the paper was to give a series of formulæ, by which, if anybody wished to put steam into their pits, they could do it with greater accuracy than before. He did not, however, think there was so much danger and difficulty as Mr. Lawrence said. The objection to steam-pipes was the heat; but, with proper conducting material, although the heat was unpleasant, it was not sufficient to endanger and bring down the roof. As to broken pipes, there should be proper appliances to signal to bank, so that if a pipe broke a signal could be sent to bank, and the steam be shut off from the boiler.

Mr. LAWRENCE—How long would it take to signal?

Professor MERIVALE—At Broomhill it would take some time, because things are not done in such a scientific way there as he would like. But there could be a means of communication in a pit ready to connect in two or three seconds, and a signal could be given and the steam shut off immediately.

The PRESIDENT proposed a vote of thanks to Mr. Merivale for his excellent paper. He quite understood the paper was prepared for the object Mr. Merivale had explained, and he thought all engineers must be under a considerable amount of obligation to him for having taken pains to show to the Institute the amount of loss which would occur from the use of steam under the conditions mentioned.

Mr. LAWRENCE seconded the vote of thanks.

The motion was agreed to, and the meeting concluded.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, DECEMBER 11TH, 1886.

SIR LOWTHIAN BELL, BART., PRESIDENT, IN THE CHAIR.

The SECRETARY read the Minutes of the previous Meeting, and reported the Proceedings of the Council.

The following gentlemen were elected, having been previously nominated :—

HONORARY MEMBER—

Mr. JAS. A. LONGRIDGE, 15, Great George Street, Westminster, London, S.W.

ORDINARY MEMBER—

Mr. C. R. BARRETT, New Seaham, Sunderland.

ASSOCIATE MEMBERS—

Mr. ALF. FALCONER BALL, 81, Wharncliffe Street, Newcastle.
Mr. R. B. DENNISTON, 79, Princes Street, Dunedin, New Zealand.
Mr. E. L. DUMAS, 29, Rue St. George, Paris.
Mr. MARTIN MULHOLLAND, Broomhill, Acklington, Northumberland.

The following gentlemen were nominated for election :—

ORDINARY MEMBER—

Mr. THOS. VARTY, Skelton Park Mines, Skelton, R.S.O., Yorkshire.

ASSOCIATE MEMBERS—

Mr. HENRY SLADE CHILDE, Wakefield.
Mr. WM. HOLT WAIN, Podmore Hall Collieries, Newcastle-under-Lyne.

STUDENT—

Mr. THOMAS FUTERS, 97, Stanhope Street, Newcastle-on-Tyne.

Professor LEBOUR read the following "Notes on the Coal-Measures of Catalonia, Spain :"—

NOTES ON THE COAL-MEASURES OF CATALONIA, SPAIN.

By Professor G. A. LEBOUR, M.A., F.G.S.

INTRODUCTION.

Spain, in 1885, produced nearly 1,000,000 tons of coal.* Most of this coal is of Carboniferous age, and is worked in coal-fields of which the principal may be tabulated as follows :—

a.—Northern coal-fields, comprising those on both sides of the Cantabrian range in the Asturias and Leon, on the southern slopes of the Sierra de Burgos in Castilla vieja, and those of Catalonia.

b.—Southern coal-fields, chiefly developed on the southern slopes of the Sierra Morena at Belmez and Espiel, to the north of Cordova, and at Villa nueva del Rio, north-west of Seville, on the right bank of the Guadalquivir in Andalusia.†

About three-fourths of the coal produced has, for many years, come from the Asturian portion of the northern division. In the present paper it is proposed to draw special attention to the Catalonian deposits of this same division, and reasons will be given for regarding these little-known fields as being, geologically, but a prolongation of those of the Asturias, and probably of much greater extent than they have been generally thought to be.

GEOGRAPHICAL POSITION.

Two coal-fields are at present recognised in Catalonia—that of Seo de Urgel, on the banks of the Segre, in Cerdaña, some 18 miles due south of the centre of the little republic of Andorra, and that of Ogassa and Surroca, usually known as the San Juan de las Abadesas coal-field, and situated near the ancient town of that name, in the hilly district between the rivers Ter and Freser, in the north-western portion of the Province of Gerona.

* The exact figures are, according to the Government statistics just issued, 919,440 tons of coal and 26,464 tons of lignite. See *Revista Minera* for November, 1886.

† See Geinitz's *Die Steinkohlen Deutschland's und anderer Länder Europa's* . . . (1865), Vol. I., p. 344. At this date Dr. Geinitz speaks of the San Juan de las Abadesas and Urgel coal deposits as not yet of commercial importance.

Seo de Urgel is still far distant from the nearest railway, though it stands upon one of the fine Government roads which are the glory of this part of mountainous Spain. San Juan de las Abadesas on the other hand, is directly connected by rail with Barcelona, a circumstance which has necessarily given much additional importance to the mineral resources with which the district abounds. As the crow flies, Barcelona is only about 55 miles from San Juan. The train, however, from the hilly nature of the ground, follows a very circuitous route.

It will be seen on glancing at the map, that both Seo de Urgel and San Juan de las Abadesas are similarly placed with reference to the watershed of the Pyrenees—both equi-distant, or nearly so, from the main crest of that great range, and both among the deeply sculptured and lofty foothills near the base of its southern flanks. In a straight line, the distance between the two coal-fields is a little under 40 miles.

THE COAL-MEASURES OF OGASSA AND SURROCA.

For several years workings for coal have been carried on here on a fairly large scale, and these, which are still successfully continued, with all the most modern appliances, at Surroca, enable one to study with ease the characters of the seams and those of the rocks with which they are associated.

In the summer of 1884, the writer had the advantage of going very carefully over this coal-field, visiting all the workings, and surveying, geologically, the whole of the neighbourhood, in the company of Señor Don Juan Villarasa, whose knowledge of the locality was of the greatest help to him. Much valuable information was at the same time given him by Señor Don Ramon Vidal, the mining engineer in charge of the coal mines.

That the coal-bearing rocks here are of true Coal-Measure age there can be no manner of doubt. The fossil plants, of which there are many in a beautiful state of preservation, are sufficient to prove this at a glance. Fronds of *Sphenopteris* and *Neuropteris*, stems of *Calamites* and large *Cordaites* leaves are common in the shales, and where these are associated, as they frequently are, with clay ironstone, the fern remains are preserved in relief with a very unusual degree of detail. These shales have, in fact, exactly the character of the ordinary Upper Carboniferous shales of the English or French coal-fields. They are fairly thick, and alternate with thinner sandstones. The latter are usually fine-grained, except near the base of the series, where there are indications of their becoming coarser. Some writers have not feared to correlate these lower coarse-grained grits

with the Millstone Grit of England; but at present to admit such a correlation, though it might possibly be true, would seem rash in the extreme. No fossils were observed in the sandstones, and it may be stated at once, that no Sigillarian, Lepidodendroid, or Stigmarian plant remains were at any time seen by the writer in this district, a negative fact to be taken, of course, only for what it may be worth.

A very fine continuous section of the shales and sandstones, showing at least 700 feet of these beds, is exposed in the ravine of the Foganella torrent, a mountain stream a little to the east of Surroca. (See Fig. 1, Plate II.) The strata here dip at a very high angle to the south—that is to say, away from the high mountain ridges—and, generally speaking, this statement must be taken as holding good for all the visible Coal-Measures cropping out to the day in the Ogassa-Surroca area. Southerly dips of from 35 degs. to 90 degs.—more often approaching the vertical than not—are the rule.

The coal seams at present known and worked in these Coal-Measures are three in number, varying from 6 feet to 26, 30, and 37 feet in thickness, and are, it would appear, associated rather with the shales than with the sandstones. The coal is of fairly good quality, is capable of producing good coke, and at present is chiefly manufactured into briquettes.* In places only the coal seems to have a tendency to become slightly anthracitic, but this is a peculiarity confined strictly to limited portions of the mines, and due, possibly, to local disturbances. Owing to the high dips the seams are necessarily worked much in the same way as metalliferous lodes, or like so many of the coals of the southern French coal-fields. What the entire thickness of the Coal-Measures may be the writer is unable to state, for reasons which, he trusts, will be presently apparent; but, judging from the various sections which he was

* Analysis of coal from the "Faro" Mine (a large concession adjoining that of the San Juan Mines):—

Fixed Carbon	69·20 per cent.
Volatile Matters other than Sulphur and Water	17·85 „
Sulphur	2·32 „
Ash	9·72 „
Water	0·91 „
	100·00 „

Coke	80·1 per cent.
Volatile Matters	19·9 „
	100·0

The coal cokes well. The residual coke will contain about 12 per cent. ash, and about 1·6 per cent. of sulphur. (Signed) JOHN PATTINSON.

enabled to measure, he is inclined to the belief that altogether the series cannot be less than from 1,200 feet to 1,500 feet thick, and may be considerably more.*

The area over which the Coal-Measures crop out to the day here is of about 200 square kilometres, but this, by no means, represents the extent of the workable coal-field.

THE COAL-MEASURES OF SEO DE URGEL.

These beds were, the writer believes, first recognised in Spanish Cerdaña by M. Noblemaire† in 1857. Since then, coal has been proved in many places in the immediate neighbourhood, and has been worked. It differs from that of Surroca, in being more anthracitic. Otherwise, the Coal-Measures in both localities are very similar—the same grits and sandstones, the same shales with the same fossil plants, the same seams, the same high southerly dip, and the same strike; in fact, there can be no doubt at all that the two coal-fields were formed at the same time, were probably continuous, and may be so still, though the area of the Coal-Measure *outcrop* at Urgel is much smaller than that at Ogassa-Surroca.‡

* It may be of interest to mining readers to know that, at the time of the writer's visit, the San Juan de las Abadesas coal-mine at Surroca employed 600 men when in full work, 200 at the surface, and 400 below ground. In the summer many of the miners leave to work in the fields on neighbouring farms, etc. The maximum daily output was 200 tons, the average 150 tons. A number of elaborately constructed inclined planes connect the various parts of the mine with the mineral line which runs from Surroca to San Juan de las Abadesas, and form a very marked feature of this mountain colliery. Owing to the fact that the coal crops out along a high mountain flank with a steep slope, as will be seen from the sketch-sections accompanying this paper, all the workings are carried on by means of levels, the lowest of which carry off all the water.

† See "Etude sur les richesses minérales du district de la Seo d'Urgel (Catalogue)." *Annales des Mines*, Sér. 5, Vol. XIV. (1858), pp. 49-75.

‡ Noblemaire gives the following analyses of Seo de Urgel coal:—

	I.	II.
Volatile matter	9·75	8·75
Carbon	67·65	85·78
Ash	22·60	5·47
	100·00	100·00

Or, omitting the ash in the second and purer sample—

	II.
Volatile matter	9·26
Carbon	90·74
	100·00

The ash was composed of—

Ferruginous clay	40·00
And quartz	60·00
	100·00

ROCKS BENEATH THE COAL-MEASURES.

At Ogassa and Surroca, in the San Juan de las Abadesas district, the Coal-Measures are, at their northern (and therefore lower) boundary, everywhere seen to be in contact with a thick calcareous series, forming bold east and west cliff-like escarpments facing south. In places, the writer observed bands of crowded goniatites in this limestone together with several large orthoceratites, together with a few corals; but he has not been able to determine the species with any degree of certainty yet. As it is, the rock in question might equally well—so far as the fossil evidence available is concerned—be Lower Carboniferous as Devonian. Considering, however, the conclusive proofs which Dr. Ch. Barrois has recently adduced, that the exactly similarly situated limestones of the Asturias are of Mountain Limestone or Lower Carboniferous age, one is much tempted to jump to the same conclusion here. The writer however, though he searched hard, entirely failed to find any clear proof of the conformable superposition of the Coal-Measures on the limestone. Everywhere, as above stated, the two were in contact, but the boundary between them might, in some cases, be a faulted one—and faults abound in the neighbourhood—or, in others, it might be an unconformity. The latter supposition gathers strength from the state of things at Seo de Urgel, where the Coal-Measures are clearly seen to rest, unconformably, not upon limestone, it is true, but upon older schists. The Ogassa limestone beds may, therefore, for the purposes of this paper, be called Carbo-Devonian, in absence of positive proof as to their age. At any rate, they lie upon older schists similar to those below the coal-bearing beds at Urgel, probably of Silurian age, and forming part of the great central crystalline core of the Pyrenean range.

ROCKS ABOVE THE COAL-MEASURES.

To describe briefly the section beautifully exposed from the town of San Juan de las Abadesas to the mines at Surroca will give an excellent idea of the nature of the stratigraphical succession above the Coal-Measures. San Juan itself stands at the junction between two important members of the Secondary series, both, however, so unlike the developments of such rocks in northern Europe, as to be extremely puzzling to a newcomer. The general dip of all the rocks—neglecting all the numerous local and merely temporary changes of direction—is to the south, the amount increasing gradually as one proceeds from north to south, or, in other words, as one gets into older rocks. Taking each great division in order, beginning with the highest, there are—

(a.) Upper Red Beds. — These consist of a very thick series of bright red arenaceous beds of great thickness, having all the physical characters which are usually associated in one's mind with the Trias of Permian. Huge irregular masses of gypsum are interbedded in abundance among these red beds. The latter are often pebble beds of great coarseness, and much false bedded. The road from San Juan to Olott, and the left banks of the Ter, immediately below the town, exhibit magnificent sections of these singular deposits, which, in this district at least, are unfortunately devoid of fossils. They are regarded as of Garumnian age, though positive proof of this is wanting. Their relations with the succeeding beds beneath are quite clearly shown, and admit of no question.

(b.) Blue Marls.—This, again, is a thick series of unusual appearance. It consists of a mass of very homogeneous greyish blue marks, containing here and there a few imperfect fossils, which leave some doubt as to the exact age of the formation. It has been more than once described as Cretaceous. The right banks of the Ter, from San Juan to Ripoll, and along the railway between these two places, is one continuous open section of these rocks, the sameness of which over several miles of country is very striking. The narrow valley of the Surroca river, or torrent, as it is locally termed, shows an equally good section of these rocks. An attempt is made in the diagrammatic section (Fig. 1, Plate III.) to indicate the constant rolling of these blue beds in parallel synclinal and anticlinal folds, the axes of which run in the same direction as the strike, or, in other words, parallel to the mountain ranges to the south. Many faults of varying throws are shown in these rocks, but for the purposes of this paper may with advantage be left out of consideration, as not in any way essential to the point sought to be established. Next below the Blue Marl series comes a thick and remarkable group of

(c.) Jurassic Rocks, chiefly of *Liassic* age, it is thought, and consisting of fine compact grey and cream-coloured limestones and cementstones, which, running in a very persistent band of bold escarpments across the country for miles, form one of the most useful guiding horizons to the south of the high mountains. These Jurassic strata are separated from the overlying Marls by a great unconformity, the amount of which, however, it is difficult to realise in the field owing to the violent contortions to which, as the general dip increases rapidly in amount on approaching the crystalline rocks, all the beds have been subjected. These contortions are in many cases locally accompanied by inversion, as in the grand outcrop of the Secondary limestones near Camprodon, at

the eastern extremity and south-west of the Col de Jou, at the western extremity of the Surroca-Ogassa coal-field (see Figs. 1 and 2, Plate V.).

Fossils, though occasionally found, are singularly rare in these Jurassic rocks.

The more argillaceous limestones of this series yield excellent cement-making material, and several manufactories of hydraulic cement are established along this broad outcrop. In several places the stone is highly bituminous, so-called "mineral tar" oozing out freely from the fissures of a newly exposed surface. Some slight attempts to turn this characteristic to account have from time to time been made, as on the left bank of the Ter, below Camprodon, but hitherto without tangible result.

This series lie apparently quite conformably upon that immediately beneath it—an unfossiliferous series of massive *red sandstones*, with occasional conglomerates, the age of which has long been a subject of contention among Pyrenean geologists, but which, since it is manifestly older than the overlying Lias, and newer than the underlying Coal-Measures, one cannot err very seriously in calling

(d.) New Red Sandstone, a name which leaves the question of Permian or Triassic open, while it sufficiently clearly indicates the position occupied in the geological scale by the rocks in question.

Strangely enough, Noblemaire, in the able paper previously referred to, though he there perfectly satisfactorily, and for the first time, proves the unconformity of this red series upon the Coal-Measures in the Seo de Urgel district, yet tries to show that it is of Cretaceous age—an entirely untenable conclusion, when the field of observation is extended from the banks of the Segre to those of the Freser or Ter. To those earlier investigators to whom the unconformity between the two formations was unknown, it is not to be wondered at that the red beds appeared to be but the upper portion of the Coal-Measures. At the present time the Trias is the stratigraphical division to which those few geologists who have paid any attention to the question seem disposed to refer the red series, though there is almost as much to be said in favour of their Permian age.

An irregular but thick dyke, or sheet of Felstone Porphyry,* cuts along the strike, through the New Red rocks, and has been traced by the writer from the Moor's Tower (see Fig. 1, Plate II.), near Camprodon, to Ogassa, a little east of the Col de Jou.

* Owing to the nearly vertical position of the encasing beds, it is here not easy to tell a dyke from an interbedded sheet.

UNCONFORMITIES, AND THEIR RESULTS.

Unconformably then, below the New Red series, come the *Coal-Measures* as described above, both at Surroca and at Seo de Urgel. Moreover, the same relation between these groups of strata has been recognised in similarly situated small coal-fields on the north, or French, side of the Eastern Pyrenees, and not only there, but in those other Spanish coal-fields of the northern zone, which have already been mentioned as hitherto the most important in the Peninsula—those, namely, of the Asturias.

But, though the same relative position can be shown to exist wherever, on either side of the Cantabrian and Pyrenean chains, the Coal-Measures and the New Red Sandstone are both found cropping out to the day; this is by no means the state of things open to surface observation along two continuous bands, from the Atlantic to the Mediterranean.

The lie of the beds, at Ogassa, seems to the writer, to give the key to the *underground* structure of the country, along those long stretches of hilly ground, which intervene between the few and small open coal-fields (for the largest are small), known up to the present.

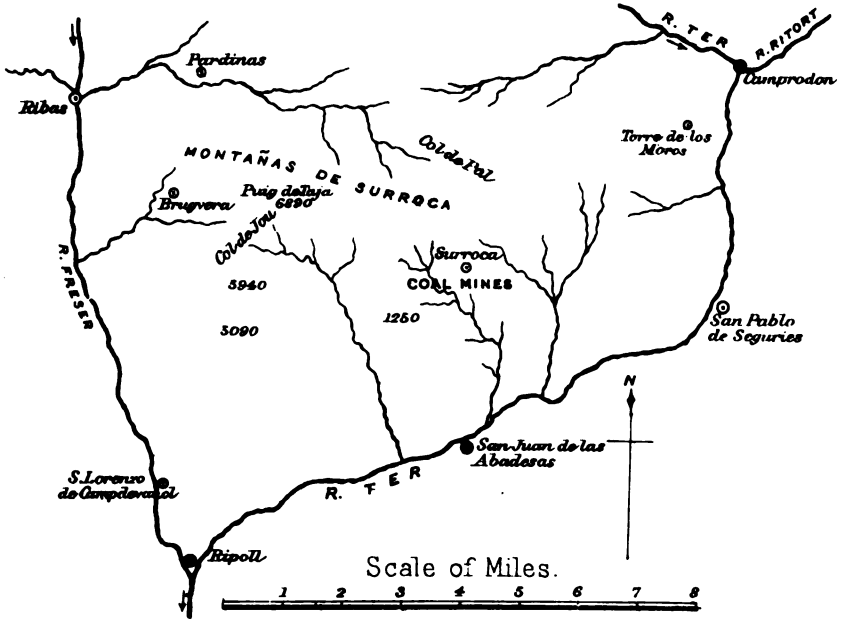
This lie of the beds depends upon the transgressive stratification, due to the unconformities already noted as occurring—1st, between the Blue Marls and the Jurassic; 2nd, between the New Red Sandstone and the Coal-Measures; 3rd, probably between Coal-Measures and the Carbo-Devonian Limestones; and 4th, between the latter and the crystalline schists of the central chain. The diagrammatic sections (Figs. 1, 2, and 3, Plate IV.), all taken from nature, though not drawn to scale, will sufficiently explain the point. These sections will be best understood in connexion with the sketch plan on Plate III. (Fig. 2.)

At Surroca, the Coal-Measures are most probably only in part exposed, the upper portions being concealed by the unconformable New Red. A little west of Surroca, still less Coal-Measures are exposed, the outcrop of the New Red having crept further north over the underlying deposits. Further west still, at Ogassa itself, the Coal-Measures, though proved, are entirely concealed, and the Red beds abut against the Palæozoic Limestones.

But the Jurassic Limestones, though it has not been possible to prove an actual unconformity between them and the New Red Sandstones, yet seem to overlap them, and accordingly at the Col de Jou, only a little westward of Ogassa, the Red beds are concealed as well as the Coal-Measures, and the Jurassic abut against the Carbo-Devonian Limestones. Elsewhere, as near Ribas, they even cover up the latter rocks and lie side by side with the crystalline schists.

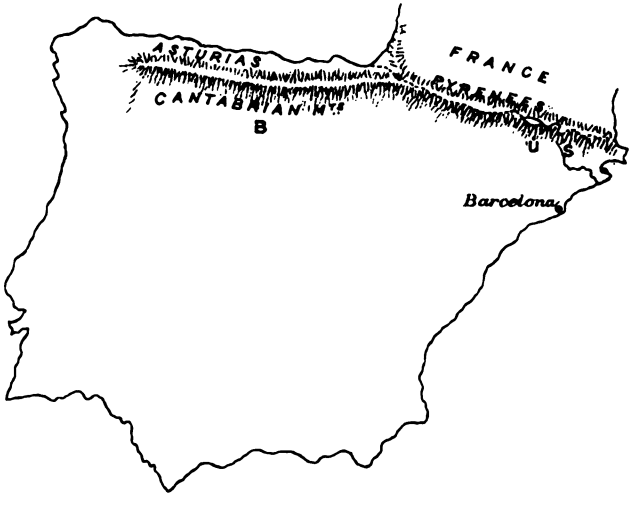
To illustrate Professor G.A.Lebour's paper "On the Coal Measures of Catalonia, Spain."

FIG. 1.



Sketch Map of the Surroca Coalfield showing the principal spots mentioned in the text. Heights in feet.

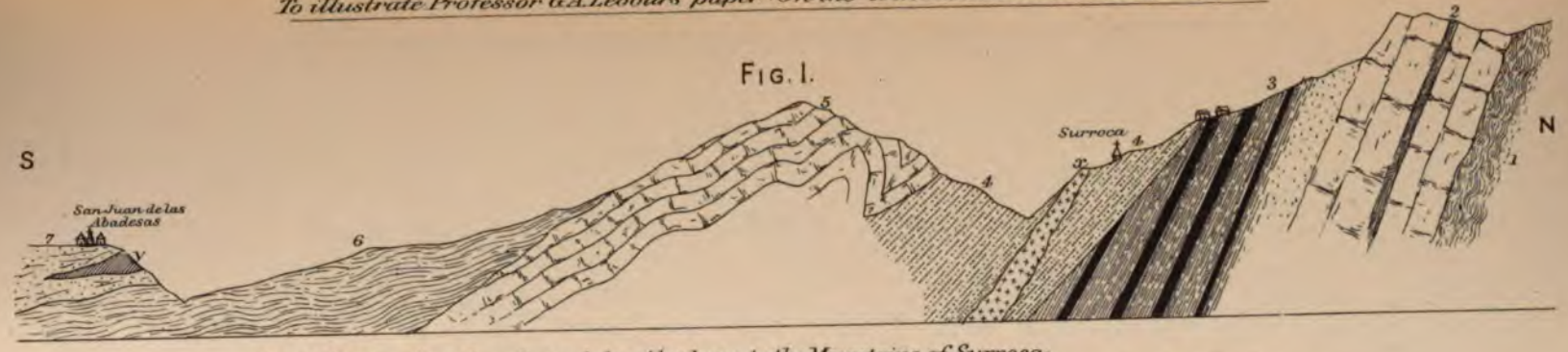
FIG. 2.



Sketch Map of the Peninsula showing the relative positions of the Northern Coalfields, namely: those of Catalonia, U = Urgel; S = Surroca, and those of the Asturias and on the Southern side of the Cantabrian chain, B = Burgos.

To illustrate Professor G.A. Lebour's paper "On the Coal Measures of Catalonia, Spain".

Fig. 1.



Sketch Section from San Juan de las Abadesas to the Mountains of Surroca.
1- Crystalline Schists (Silurian etc) 2- Carbo-Devonian Limestone. 3- Coal Measures. 4- New Red Sandstone
5- Jurassic Rocks. 6- Blue Marls. 7- Red Conglomerates. x- Felstone Porphyry. y- Gypsum.

Fig. 2.

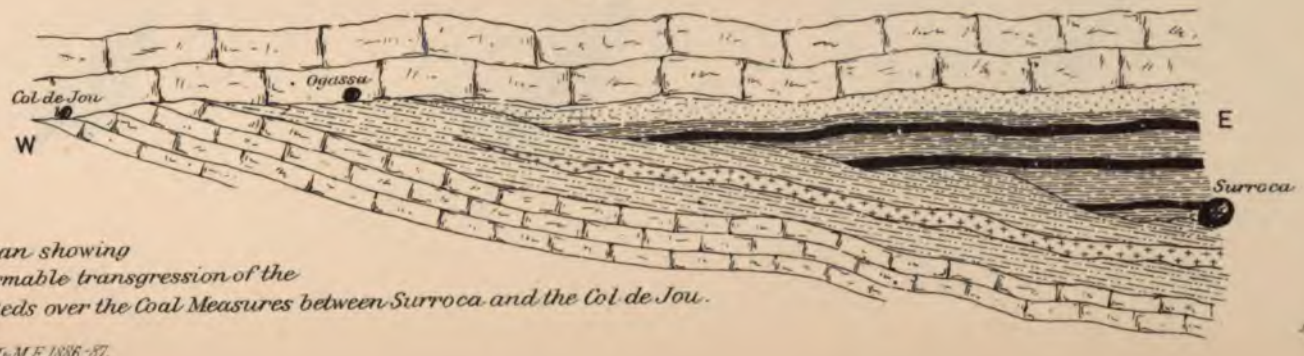


Diagram Plan showing
the unconformable transgression of the
Secondary Beds over the Coal Measures between Surroca and the Col de Jou.

To illustrate Professor G.A. Lebour's paper "On the Coal Measures of Catalonia, Spain."

FIG. 1.

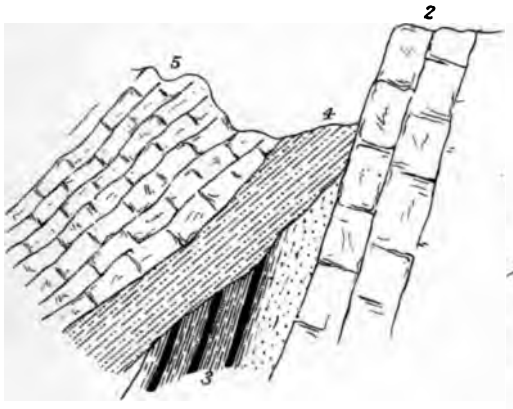


FIG. 2.

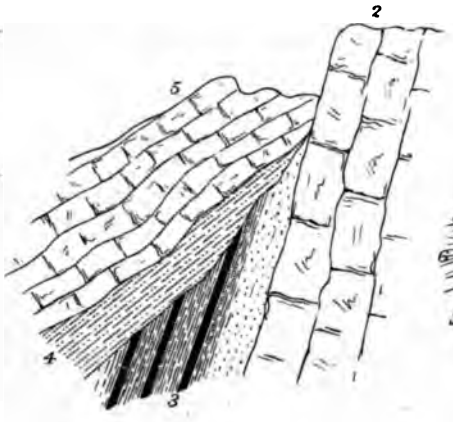
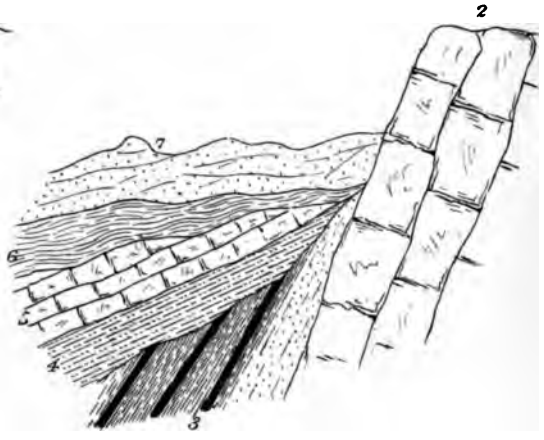


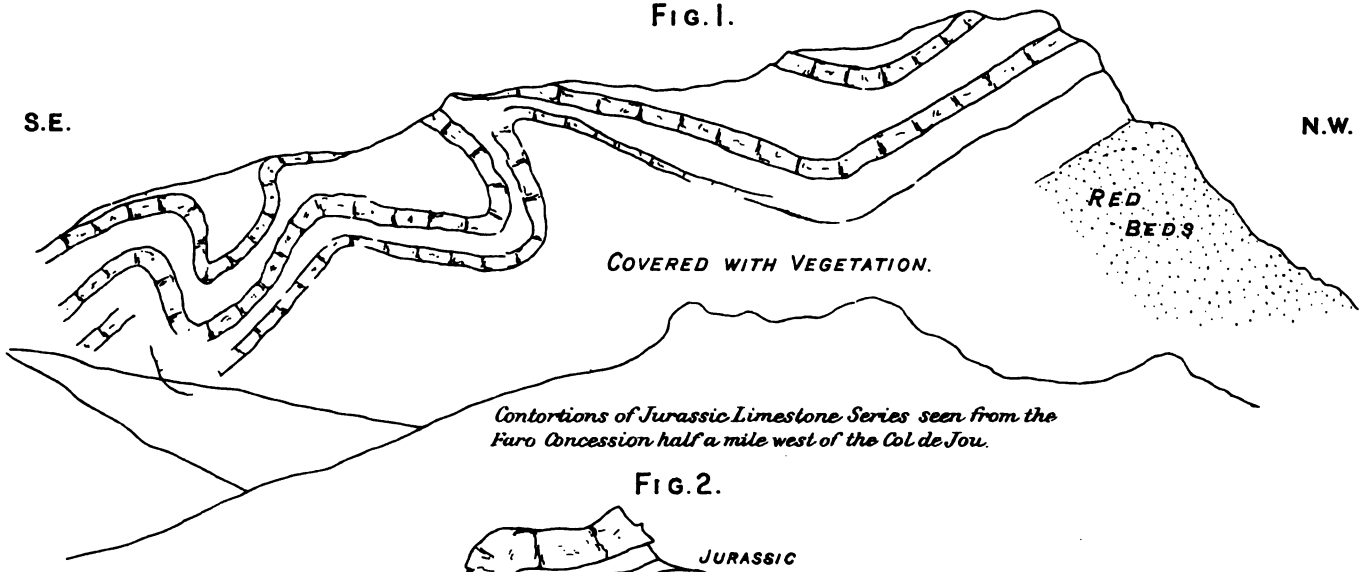
FIG. 3.



At the Press Newcastle

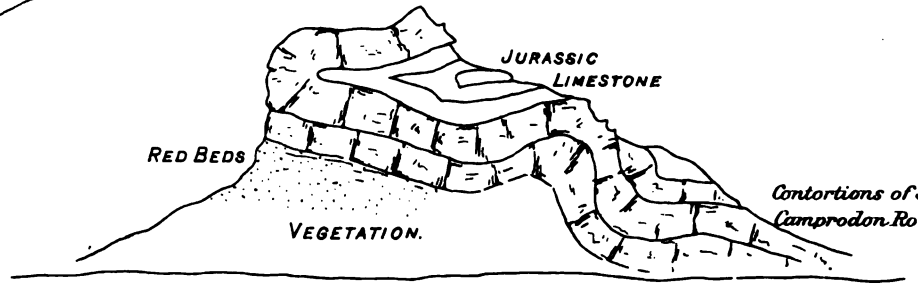
To illustrate Professor G.A. Lebour's paper "On the Coal Measures of Catalonia, Spain."

FIG. 1.



Contortions of Jurassic Limestone Series seen from the Faro Concession half a mile west of the Col de Jou.

FIG. 2.



Contortions of Jurassic Limestone seen from the Camprodon Road a little to the south of that Town.

In an exactly similar way the unconformable Blue Marls and Garumnian Upper Red beds by transgression and overlap, are found in many places between the Catalonian fields and those of the Asturias, to conceal the Jurassic rocks and to abut, apparently, but not really, without intervening deposits, upon the older metamorphic core of the long east and west mountain chains.

CONCLUSION.

It follows from the considerations above set forth, that, though the absolute continuity of the Coal-Measures, from Catalonia to the Asturias, is not probable, yet, that a vast extension of these beds, beyond the places at which they are seen out-cropping to the day, is very likely, and that the failure to recognise this important fact has been due, partly to the erroneous determination of the ages of some of the great divisions overlying the Carboniferous rocks, and chiefly to want of proof of the several unconformities involved.

With exploratory researches carried on in the light of the geological facts, above described, it is thought that the determination of the existence of a long zone of valuable coal-fields in Northern Spain is only a matter of time.

Professor LEBOUR, in reply to the President, said, that the same seams which have been worked at the colliery extend, where they crop out at the surface, over an area of 200 square kilometres, and, if his theory was correct, they extend over a very much larger area in a westerly direction; and it was his opinion that there was no reason, then, why Spain should not in time be able to furnish a large quantity of coal.

Mr. E. R. BRYANT said, he knew the district of which Professor Lebour had been speaking. The mine was in the hands of a very large company, who owned the railways to France; it was producing about 60,000 tons a year and it was expected that the output would very shortly be brought up to 100,000 tons. Most of the coal was made into patent fuel for use on the company's railway and other railways. Pains were not taken to bring the coal out in large pieces, because it was made into briquettes. One colliery was in the hands of people who, he thought, were likely to work it in connection with iron mines.

The PRESIDENT asked if it was a good coking coal?

Professor LEBOUR said, that would be seen by the analyst's note.

Mr. BRYANT—Mr. Pattinson, the analyst, is of opinion that it will make very good coke.

The PRESIDENT—It is a very difficult thing to pronounce an opinion off hand as to what kind of coke a particular coal will make, but the analyst says it cokes well.

Mr. BRYANT, in reply to Professor Merivale, stated that the coal was washed before it was made into briquettes. He did not know the percentage of ash in the briquettes.

On the motion of the President, seconded by Mr. A. L. Steavenson, a unanimous vote of thanks was passed to Professor Lebour for his paper.

Mr. M. WALTON BROWN read "An Account of Experiments in France upon the possible connection between Movements of the Earth's Crust and the Issues of Gases in Mines."

AN ACCOUNT OF EXPERIMENTS IN FRANCE UPON THE POSSIBLE CONNECTION BETWEEN MOVEMENTS OF THE EARTH'S CRUST AND THE ISSUES OF GASES IN MINES.

By M. WALTON BROWN.

The French Government appointed a special committee, in 1883, to make personal inquiries, as to the methods of observation of movements of the earth's crust, and the results obtained in Italy. This was done with the intention of not neglecting any chance of obtaining means of protecting miners against their most dangerous enemy, gas, which continually threatens them; together with the project of establishing a number of seismological observatories in France.

Upon the report of the special committee, the French Government placed a tromometer and a micro-seismograph at the School of Mines, Paris; and a tromometer at the School of Mines, Douai.

The tromometers have been observed daily from the 1st of February, 1886.

The observations have been recorded in the four first columns of the following form of register, the other columns containing the results of meteorological observations :—

Seismological Observatory.

Month of ..... Station at .....

Date.	Hour.	Tromometer.		Barometer, reduced to sea level.	Wind.		Temperature.	Remarks.
		Amount of oscillations.	Direction of oscillations.		Force.	Direction.		

The tromometer at Paris has recorded almost insensible movements, although repose was anticipated, as the Paris basin is essentially stable. The micro-seismograph, erected close to the tromometer, but which has

not been completed with a self-recording apparatus, will probably afford, by continuous diagrams, the means of judging whether the small movements observed are caused by the disturbances of the town, or are connected with some endogenous cause.

The observations at Douai, are already of some interest by the connection between the intensities of the oscillations, the barometric variations, and the issue of fire-damp.

The barometric readings were communicated by the meteorological station at Douai.

The observations of the escape of fire-damp have been made by means of the Pieler lamp, at the Herin Colliery of the Anzin Collieries Company.

The diagram shows the three classes of variations by three lines whose ordinates are drawn upon the same abscissa, representing time. (Figs. 1, 2, 3, Plate VI.)

A comparative examination of these lines shows that, altogether there is a marked correlation between the three classes of phenomena. The maxima and minima do not exactly correspond as to time, but there is a perfect coincidence between the two lowest readings of the barometer (February 1st and March 3rd), and the greatest intensities of microseismic motions and of percentages of fire-damp.

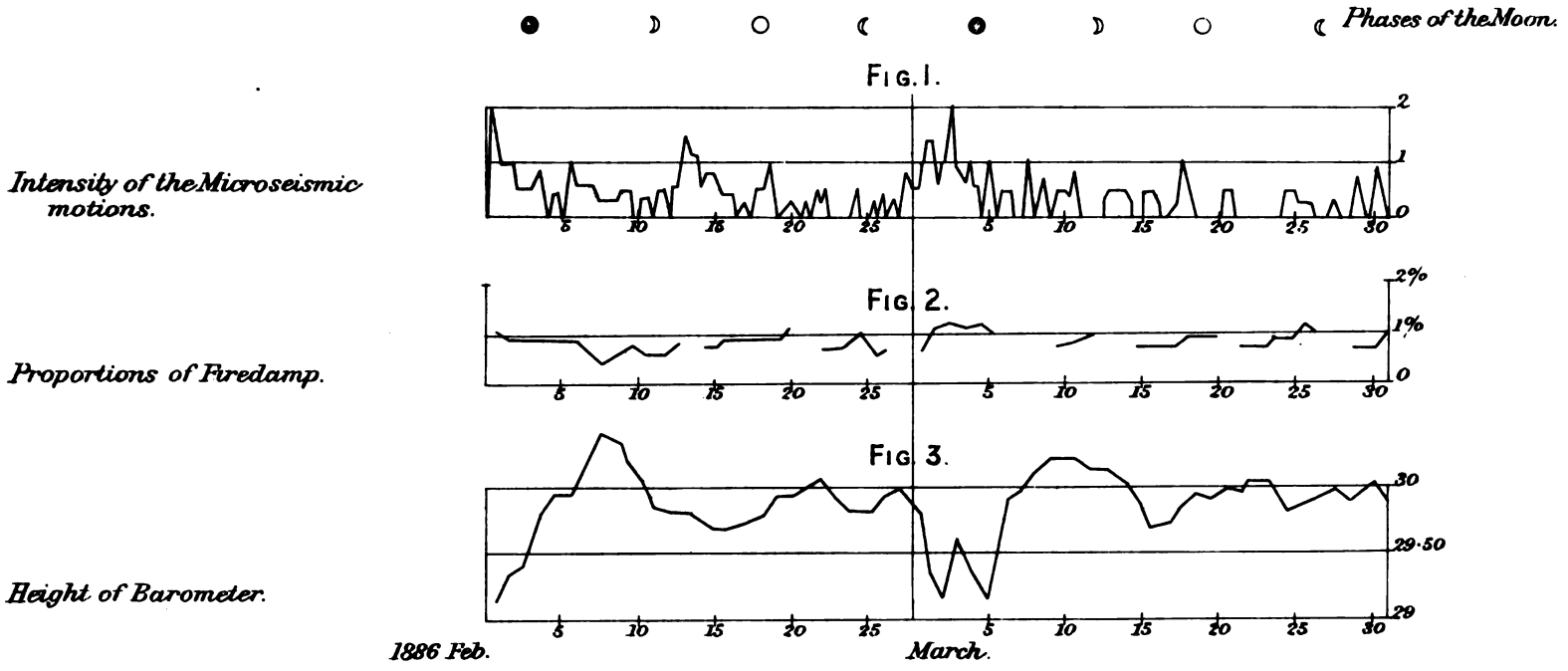
The breaks in the fire-damp line are days of rest, and the proportion of fire-damp nearly always regularly increased from the beginning to the end of the week ; and this will, to some extent, mask the effects due to the barometric and seismic movements.

The significance of the correlation furnished by the short period of the observations must not be exaggerated, but the coincidences may at least be considered as an encouragement to continue the observations, which are intended to discover the connection which may exist between seismic phenomena and issues of fire-damp.

The coincidences between increases of seismic activity and barometric depressions appear already to prove that, if these depressions favour the issue of fire-damp, it is perhaps less by the effect of exhaustion upon the exposed coal than as a sequence of the compressions produced by them as local distortions of parts of the earth's crust, which contains the seams or the volumes of gas.

This summary is derived from a detailed account of the observations contained in the *Annales des Mines*, 8th Series, Vol. IX., pages 207 to 281, and Plates V. and VI.

To illustrate M.r M. Walton Brown's paper "An account of experiments in France upon the possible connection between movements of the Earth's crust and the issues of Gases in Mines."



Mr. STEAVENSON said, they were much indebted to Mr. Brown for keeping the Institute informed of what was going on upon the Continent. The record was a very important one; and it was most desirable to know what were the laws which should guide them in their endeavours to guard against the appearance of their subtle enemy—gas; and he, therefore, proposed a vote of thanks to Mr. Brown for his paper, which was passed unanimously.

The following paper by Mr. Henry White, on "Lightning in the pit at West Thornley," was read:—

REMARKS ON A FURTHER DISCHARGE OF LIGHTNING AT THE WEST THORNLEY COLLIERY, NEAR TOW LAW, ON OCTOBER 21ST, 1886.

By HENRY WHITE.

THE following remarks on another discharge of lightning at the West Thornley Colliery, afford a further confirmation of lightning going down the pit, and more particularly as to its power of travelling a considerable distance in-bye, notwithstanding the fact of a lightning conductor having been attached to the chimney, after it was damaged on December 11th, 1883. See Vol. XXXIII., page 81.

The chimney and conductor are now about 76 feet high, 25 feet higher than the pulleys, and only 68 feet distant from them; bearing out the theory that the area or space protected by a conductor is in the form of a cone, whose base is equal to its height.

On the Thursday afternoon, October 21, 1886, there was a very severe thunderstorm, with much rain, and the lightning went down the pit twice in about five minutes, as is shown by the following evidence:—

John Batey, onsetter, who was at the pit bottom, says that when standing on the flat sheets, about 4 feet from the cage on the east side of pit, the pit bottom was lighted up by a flash of lightning, which appeared to have come down the east side rope (cage standing at the bottom at the time), or the one furthest from the steam and other pipes.

Robert Chambers, who was about 12 yards from the pit bottom, and shoving an empty tub along the shaft siding, says he would be about 18 inches from the steam and water pipes when he saw the lightning; he was struck on the elbow, and felt a pain or numbness in it for the rest of that day and the following one.

W. R. Teasdale, the hauling engineman (40 yards from pit bottom), was running the sett in-bye when his engine house was lighted up, and he heard a noise like a pistol shot, and thought some part of his engine had broken. After the sett had got in-bye, and when examining the engine which was then standing, he saw another flash about five minutes after the first.

Robert Simpson, the landing lad in the top coal landing, about 660 yards from the shaft bottom, says when in the landing the place was lighted up, apparently on the tail rope side, and he heard a fizzing or crackling like a squib. About five minutes afterwards he and the driver lad saw this repeated.

A few months after the previous discharge, December 11, 1883, Mr. Heaviside, of the Post Office Telegraph Department, and a friend of his, made a very careful examination of the place and its surroundings, and wrote Mr. Heaviside as follows :—

7, Grafton Road, Whitley,
Newcastle-on-Tyne,
April 4th, 1884.

Henry White, Esq., Tow Law.

Dear Sir,

Referring to our examination of the scene of the lightning discharge at West Thornley, on December 11th, 1883, a probable explanation of the phenomenon is as follows :—

The highly electrified storm cloud, hurrying violently along with the wind from the W.N.W., would pass over the hill to the W.N.W. of West Thornley Colliery, and then suddenly drive over the colliery, inducing, in the mass of metallic conductors (steam-pipes, boilers, and ropes, etc.), good and bad, concentrated at that point, electricity of the opposite kind to its own, and owing to the convenience of discharge at that particular place, due to the presence of the colliery plant in general providing better conductors to earth than other objects in the immediate neighbourhood, it would strike every point that would assist in the discharge, as it were, everything in favour of a charge and discharge was focussed at that particular point. The first object in the storm cloud's path was the chimney, which, being a refractory conductor, was rent and fractured, until the current of high electro-motive force reached a point 15 feet from the bottom of the chimney, where a metallic connection was met, made by means of an iron stay attached to a steam-pipe from the boilers for the support of the steam-pipe. The stay, the steam-pipe, and the gear attached, formed part of a continuous good conductor, from the surface to the bottom of the pit, where, probably, the largest portion of the electricity would be discharged; but inducing in everything within range of its path electricity of the opposite sign, from which sparks, or luminous discharge, with the ordinary accompaniments of the ozone smell, described as vapour, and noise would be given off, hence the discharge between the rapper handle and the steam-pipes at the bottom of the pit.

Had the pulleys, etc., been the first objects in the path of the storm, *i.e.*, had the storm been coming the opposite way, probably the chimney would not have suffered, as the ropes, pulleys, and gear attached are much better conductors than the chimney, and might have sufficed to effect the discharge. But one cannot be dogmatic in such matters of opinion, because lightning discharges appear to be capricious, due to our imperfect knowledge of the subject.

In such accidents it would be interesting to know, as in this case, whether the injury is in the direction from whence the storm comes, and also whether accompanied by rain or other natural effects.

Yours very truly,
A. W. Heaviside.

Mr. SWAN said, he would suggest that, in any case of lightning conductors in the neighbourhood of a pit shaft, with wire ropes going down to the bottom, special and extraordinary precautions were required to make a good and extensive earth contact, either by leading the conductors into flowing water, or taking care that the current should be quickly dissipated, otherwise, the lightning conductor might be a means of leading the discharge down into the pit by way of the wire ropes in the pit shaft. This seemed to him to be the practical outcome of the very interesting phenomenon described in the paper.

Mr. SYDNEY F. WALKER, in writing, states—The fact that the lightning discharge went down the pit, in spite of the conductor on the chimney, proves very clearly either that the conductor was inefficient, or that, as pointed out by Mr. Heaviside, the storm cloud coming from the opposite direction, the chimney conductor, with its 25 feet of air space between, was unable to discharge the cloud, in the presence of the other mass of conductors in and about the pit. The remedy is a very simple one, and one that should be adapted to every colliery, viz., set a conductor over the pit as well.

Professor MERIVALE—Perhaps Mr. Swan could give some information as to the metal connections on chimneys. A chimney is very often bound with iron bands. Should any extra precautions be taken as to the conductors? and should they be put in connection with the bands?

Mr. SWAN—It is quite understood that every conductor should be joined with every mass of metal in its neighbourhood.

The PRESIDENT—Or the rings would really be a source of danger.

Mr. STEAVENSON supposed the lightning would cause an explosion if the flash went where there was gas?

Mr. SWAN—Yes; if the atmosphere was an explosive one.

Dr. STROUD said that all metallic conductors, of course, if not in proper contact, were a source of great danger. Every precaution must be taken in this respect.

A vote of thanks was then unanimously given to Mr. White.

The following paper by Mr. E. L. Dumas on "Cuvelier's Improved Lock for Safety Lamps" was read:—

CUVELIER'S LOCK FOR SAFETY-LAMPS.

By E. L. DUMAS.

This system of safety lock has been devised in order to absolutely prevent miners from opening the lamps which are entrusted to them. For this purpose the working of the bolt (irrespective of its situation, arrangement, or the kind of lamp used) is controlled by the displacement of the ends of a flat tube, bent on itself, similar to the manometric tubes of metallic pressure gauges, which tube is arranged so as to receive liquid under pressure from an accumulating apparatus. This accumulator could be placed in the lamp room, or at any other convenient place, but, in any case, out of reach of the miners.

Plate VII. shows the arrangement adopted in practice for the application of the system to miners' safety-lamps. Fig. 1 is a horizontal section of the lamp, showing the position of the manometric tube beneath the oil reservoir. Fig. 2 shows the position of the ends of the manometric tube keeping the lamp closed ; and Fig. 3 shows their position allowing the lamp to open.

It will be seen by these drawings that the bolt which prevents the unscrewing of the upper part of the lamp, consists of a metal rod *a*, furnished with a collar *b* at its lower end, and contained in a tube *c* soldered inside the reservoir *r*. A spiral spring *d* tends to keep the bolt depressed, that is in the position which allows the opening of the lamp. Under the oil vessel is placed a manometric tube *e*, whose free extremities are terminated by catches *f* resting on a shoulder *g*, which also guides the lower portion of the bolt *a*. The central part of the curved tube *e* carries a socket *h*, soldered to the base of the lamp, and furnished with an opening *i*, ·01 inch (·25 mm.) in diameter. By this opening the liquid, on whose presence or absence depends the widening or narrowing of the space between the two branches of the tube, is forced in under pressure. Supposing the lamp to be closed, and the bolt *a* in the position shown in Figs. 1 and 2, it will be seen that the catches *f*, which terminate the manometric tube *e*, are pushed forward and kept in place by the elasticity of the tube, under the collar *b* of the bolt. But as soon as the compressed liquid enters the tube *e* the two branches

diverge automatically, and over a sufficient distance to allow of the rod *a* coming down under the pressure of the spiral spring *d*. When the liquid ceases to be forced in, the catches rest upon the collar *b*, as shown in Fig. 3, and the lamp may be opened and freely handled.

When the lamp has been made ready for use, and the upper part has been again screwed on to the reservoir *r*, the resistance of the spring *d* is overcome by pushing slightly the bolt *a* (in the direction shown by the arrow), with a metal rod introduced into an orifice left in the middle of the shoulder *g*. After the bolt has been brought back to the position shown in Fig. 2, the catches, being acted upon by the elasticity of the tube *e*, immediately approach one another, and slide again under the collar *b*, and the perfect closing of the lamp is thus ensured. A plate *j*, soldered or riveted to the under part of the reservoir *r*, closes perfectly the small chamber which contains the manometric tube; this latter cannot, therefore, be tampered with. Moreover, other catches *k*, Fig. 1, limit the displacement of the branches of the tube.

ACCUMULATOR.

Finally, the equality of the branches of the tube neutralises the effect of lateral shocks. It will also be noted that the small diameter of the orifice *i* (·25 or ·20 mm. = ·00985 or ·00745 inch), situated in the external part of the manometric tube, tends to keep the latter always full, and the bolt can thus be lowered instantaneously on placing the lamp on the accumulator, for it will then require a very small amount of compressed liquid to cause the branches of the tube to diverge.

Plate VIII. shows the accumulator used. The apparatus consists of a receiver, in cast iron, *a*, mounted on a tripod, in the middle of which is fixed a bronze force-pump, whose internal diameter is about 1·2 inch (3 cm.) In the cylinder moves a piston *c*, provided with double leathers. This pump is provided with a delivery pipe *d*, which is destined to convey the liquid under pressure to the lamps. The top end of the piston *c* is screwed, and passes freely through the crosshead *m*, which is firmly supported by two rods fixed to the receiver *a*, but works in the fly-wheel *n*; the piston is also keyed to a crosshead *b*, which carries a weight *o*. The piston *c* and the weight are lifted up by turning around the wheel *n* when in contact with the crosshead *m*, and pressure is produced in the pump by unscrewing the wheel *n* so that it is in the position shown in the plate. The delivery pipe is provided with a stop-cock *f*, and enters the centre of a kind of mould *m*, Figs. 2 and 3, Plate VIII., upon which the external prolongation *h*, Plate VII., of the manometric

tube of the lamp is made to rest, and where it is kept immovable by means of a small lever *n*. The rods carrying the weight *o* pass through metal tubes, which are fixed to the bottom of the receiver *a*, and there are no valves or garnitures likely to get out of order. Indeed, the principal merit of the apparatus is its simplicity; it is always in working trim, and never wants repairing. It will be remembered, moreover, that once the manometric tube has been filled very little water is necessary for opening the lamp, and thus a great number may be opened without re-raising the piston of the apparatus.

The system which has been described above, has been in use in France for the last two years in two important coal mines of the Département du Nord, namely, those of the C^ie^ de Vicoigne (400 lamps), those of Louches (C^ie^ de Douchy) (800 lamps for two pits).

From experiments made during three consecutive months in the last-named mine, it has been found that the percentage of lamps brought to the lamp room to be re-lighted, and which, as a rule, averaged only 3 per cent., rose to 10 per cent. during that time, thus conclusively proving that the miners had managed to open their lamps, and that the adoption of Cuvelier's system had put a stop to this dangerous practice.

M. CHESNEAU, Government Inspector to the *Mines du Département du Nord*, says "the system, which has been adopted by the Mining Company at Douchy, may be considered perfect, and it will be interesting to watch the effects of its more general use."

The following is the report of M. Janet, Government Inspector of Mines at Valenciennes:—

In accordance with your official letter, dated December 26th, which desired my colleague and myself to report on the results of the employment of the Cuvelier lamp at the pits near Douche after the explosion of fire-damp, which occurred there on the 26th February, 1883, we have visited the mines and obtained the following information:—

Until the end of the year 1884 the safety-lamps in use at the Douche pit were shut by means of a bolt placed in the oil reservoir; this bolt was screwed on a portion of its length, and was turned round by a socket key similar to those used for winding clocks. This mode of shutting the lamps was simple, but it was altogether inefficient, the screw being kept constantly oiled turned very easily, and could be moved by means of small pieces of wood; indeed many workmen went so far as to make false keys by cutting off the wards and using the socket of an ordinary key. The company was therefore obliged to seek a new system, and determined to try the one invented by M. Cuvelier, which consists in simply regulating the action of the bolt by means of a fluid. [Here follows a description of the lamp, which has been given above.]

The pressure necessary to open the lamps is obtained by means of accumulators

which, once charged with a pressure of 400 to 420 lbs. to the inch, open as many as from 30 to 40 lamps.

The lamp is an ordinary one on the Boty system, and weighs, empty, about 1·84 lbs., costing 5 francs. The addition of the Cuvelier system causes the same lamp to weigh 2·17 lbs., and costing 7 francs.

The accumulators are at bank, but at every lamp station a man is placed who has a certain number of open lamps to give the miners; these lamps he lights and shuts when he gives them in exchange to the miners, who bring back their extinguished lamps.

Formerly the proportion of lamps extinguished and re-lighted at the lamp station seldom exceeded 1 per cent., whereas now they have risen to more than 8 per cent.

The following Table shows the percentage during the five latter months of the year 1885:—

Month.	Lamps.		
	Supplied.	Extinguished.	%. Re-lighted.
1885.			
August	7,839	639	8·1
September	8,095	657	8·1
October	8,822	948	10·6
November	8,102	670	8·25
December	8,361	595	7·1
Total ...	41,219	3,509	8·5

It is evident, therefore, that the old mode of shutting the lamps enabled the miners to re-light them in spite of the very severe penalty attached to that act.

Finally, we think this system of shutting the lamp perfectly fulfils the object for which it was invented, and it would no doubt be advantageous to extend its employment in all fiery mines, but we do not think that it will be necessary for the Government to interfere in the matter until a longer experience has been obtained; and in all cases it is difficult to recommend any one system to the exclusion of others, for that is in fact conferring a favour which is really unjustifiable.

(Signed) L. JANET.

M. Chesneau, also a Government Mines Inspector in the Department du Nord, corroborates the above letter of M. Janet.

Mr. HECKELS took exception to one thing in the paper, for he did not think that it was conclusively proved that the miners opened their lamps.

On the motion of the President, seconded by Mr. Bunning, a unanimous vote of thanks was given to Mr. Dumas for his interesting paper.

To illustrate Mr. E. L. Dumas' paper "On Gueliers's Lock for Safety Lamps."

Fig. 1.

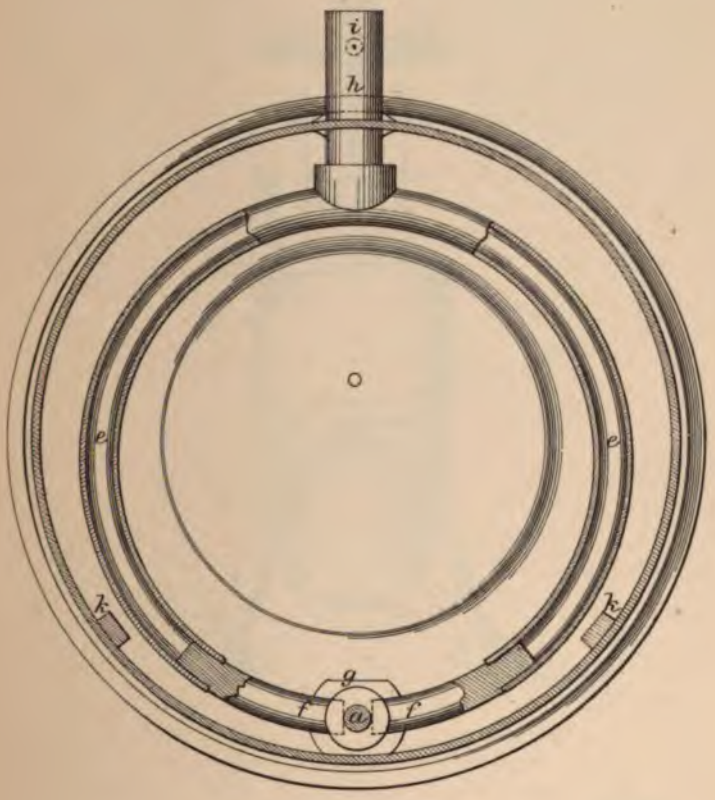


Fig. 3.

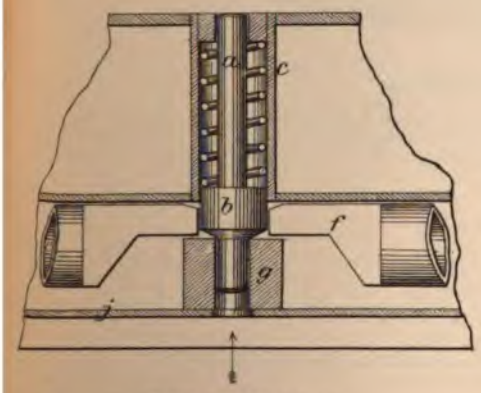
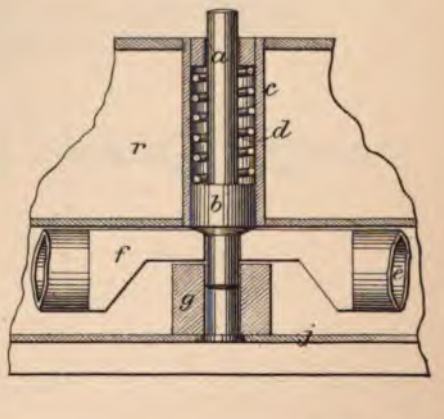


Fig. 2.



To illustrate M.r E.L.Dumas' paper "On Cavelier's Lock for Safety Lamps."

FIG. 1.

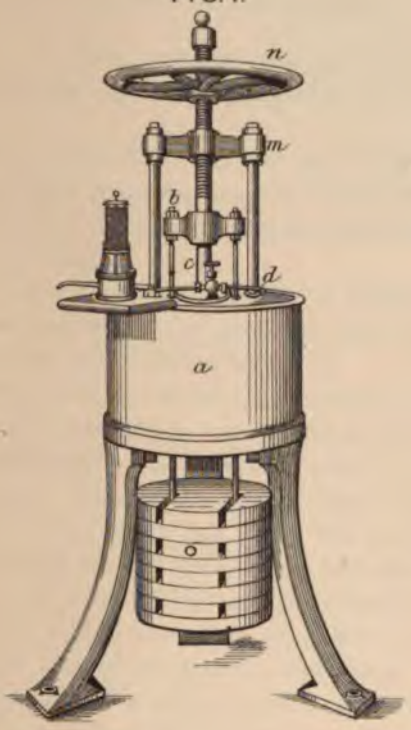
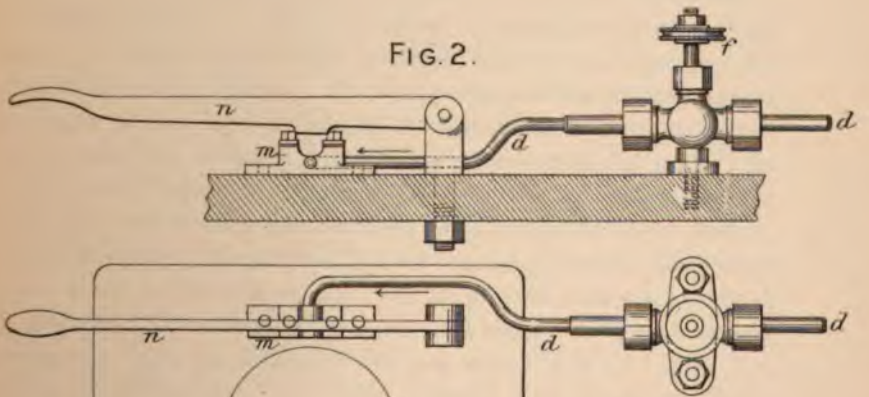


FIG. 2.



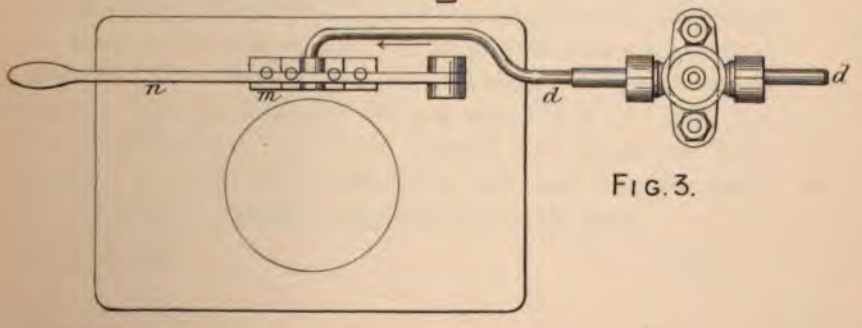


FIG. 3.

THE ELECTRIC SAFETY-LAMP.

The PRESIDENT—Mr. Swan is in the room, and the meeting will be glad to hear anything more he has to say in regard to his improved electric safety-lamp.

Mr. SWAN said he had nothing more to say. He attended to-day because he had received an intimation from the Secretary that discussion would be invited on the subject of the electric safety-lamp, which he exhibited at the last meeting.

The PRESIDENT—There was very little said in discussion upon this lamp on the last occasion, and if any gentleman has any observations to make now the meeting will be glad to hear them.

Professor MERIVALE said, he had had the advantage of being in a pit with one of Mr. Swan's lamps, and he was very much struck and pleased with the excellent light it gave. He believed he held a rather unorthodox view of the safety-lamp. His opinion was that a lamp that could stand a velocity of, say, 25 feet a second and give a very good light was the best; whereas some people thought the lamp was best which could stand 50 feet a second, or some such very high velocity, although it gave but a small light. Mr. Swan's lamp was a good one. When in the pit, the gentleman who was in front of him carried a Swan lamp, and his (Prof. M.'s) lamp went out; but, owing to the brightness from the Swan lamp, he was unaware for a time that his lamp was out. The lamp threw a strong light upon the roof and all around.

Mr. SWAN said, that the large amount of light given, as referred to by Professor Merivale, was got without over-straining the filament of the lamp. He had been exceedingly particular, in giving the capacity of the lamp, to state it moderately. It was quite easy to make an incandescent lamp give a large light by heating the filament to an abnormally high temperature, but, in doing so, they quickly destroyed the lamp. He had it clearly before his mind that the amount of light taken from the lamp must not be such an amount as would lead to the rapid destruction of the lamp. He assumed that the renewal of the lamp three times a year would be the utmost that could be afforded from considerations of economy. The amount of light that had been given by his lamp was an amount which was consistent with that durability of the lamp. Not more than 200 to 250 candles per electrical horse-power was taken from it, or, to put it into smaller figures, not more than one candle for $3\frac{3}{4}$ to 3 watts of electrical energy exacted from the lamp.

The PRESIDENT—Is it possible to state what would be the average durability of a lamp?

Mr. SWAN—Judging from a now very lengthened experience, he thought he could confidently say that the lamp would last for between 700 and 800 hours, giving an amount of light in accordance with the figures he had mentioned, namely, $3\frac{3}{4}$ to 3 watts per candle. He was glad that Professor Merivale agreed with him as to the importance of a good light.

Professor MERIVALE said, he believed he was in the minority on this point, *i.e.*, so far as the importance of a very good light over safety in very rapid currents was concerned.

The PRESIDENT supposed nobody would object to a lamp because it gave too much light.

Professor MERIVALE—Not unless it was done at the expense of safety.

Mr. SWAN said, that if it were allowable to reduce the light by half, the weight of the lamp could be reduced almost in the same proportion; but he had the idea in his mind, derived from the opinions expressed by many eminent mining engineers, who gave evidence before the late Royal Commission on accidents in mines, that a great many accidents occurred in coal mines, not from explosions, but from falls from the roof and sides, and that some of these accidents might be preventible if a better light was given by the pit lamps, and therefore he thought it better to go to the full maximum of weight that could be carried conveniently, in order to give the utmost amount of light for the examination of the state of the mine, and for doing dangerous work.

The PRESIDENT asked Mr. Swan if he was making the lamps now to any extent?

Mr. SWAN—The Edison-Swan Company are manufacturing them in considerable numbers, though to what precise extent he could not say positively; but they are going into the manufacture of the lamp on the assumption that the lamp will be required by thousands. In fact, the company had had an inquiry, to his knowledge, of the cost of 3,000 lamps, and their operations, no doubt, are based on the probability of quantities like this being called for.

Mr. THEO. WOOD BUNNING asked if Mr. Swan's ingenious arrangement for ascertaining the amount of gas in a pit, which he exhibited on the last occasion, had been practically experimented with?

Mr. SWAN said the lamp which he showed at the last meeting was left in the hands of Mr. Daglish, and he had not heard whether that gentleman had made any use of it in the pit. Excepting what Mr. Daglish might

have done with the lamp, he thought he might say there had been no experimental trial of the gas-measuring apparatus made in a pit. He had very greatly improved this apparatus since he was at the last meeting; especially in regard to the exact measurement of gas.

Mr. HECKELS said, it was a much happier position to be in to have to provide against accidents arising from preventible causes than against those which arose from causes which were not preventible. Falls of stone, and other things of that kind, were preventible accidents; but if they had lamps which would cause an explosion when in a high velocity of current, the lives of the whole of the men in the pit were endangered by a circumstance which was distinctly preventible. Probably an electric lamp was being sought for with too high an illuminating power, at the expense of lightness and portability, thus delaying the safety which would be acquired by the present use of one with less light. There was, for instance, the Marsaut lamp, which he had introduced, and which gave considerably more light than the ordinary lamps that had been used in recent years, and might be taken as a type of the amount of illumination required by the miner. If Mr. Swan would produce a lamp that would give only such an amount of light as the Marsaut, together with that perfect security from danger ensured in the electric light, he would probably secure a more rapid development of the system than would ensue from the attempts to produce a very high illuminating power.

Mr. M. WALTON BROWN asked if the use of any of the three forms of gas detectors arranged by Mr. Swan, requiring from 2 to 5 minutes each observation, would not reduce the length of time the lamp would burn?

Mr. SWAN said, the gas detector would be used periodically; the current would not be turned on to that part of the apparatus, and be left acting, but only occasional tests would be made. These occasional tests would certainly use a certain amount of the current, and this would be diverted from the lamp. But the length of time required to make a test was very short, so that the current would have to be turned on to the detector but a very short time; therefore the sum of the loss would be a very small one, and would hardly reduce the time of burning in the lamp to any sensible amount.

Mr. THEO. WOOD BUNNING—As to the weight of the lamps, they could be manufactured to suit the wants of colliery managers, who could order lamps giving more or less light, or of greater or less weight, so as to suit the various grades of workmen who had to use them. In fact, an electric lamp could be made under the same conditions of weight and light as the Davy.

Professor HERSCHEL said the ordinary lamp was exposed to danger from accidents which could not be called preventible ones. It had been proved that the flame, if not by draughts, then by shocks and explosions, had been carried through the gauze of any ordinary safety lamp; and they could hardly class these amongst preventible causes of accidents. Mr. Swan's lamp, with its perfectly guarded system, had in this respect a position of superiority over the present safety-lamp.

Mr. W. C. BLACKETT said, the ordinary safety-lamp showed automatically when there was danger present, either by flaming up or going out, and therefore it showed the presence of fire-damp or carbonic gas; Mr. Swan's lamp would keep evenly burning in any gas. He would like to know by what method, with Mr. Swan's lamp, a man would know when he was among fire-damp, or carbonic gas, without making a special test to find it out? A hewer, for instance, could not be expected to be testing every now and then for gas, exposure to which for a few minutes might be fatal.

Mr. GERVASE E. MARKHAM said, he took exception to the remarks of one of the speakers respecting accidents being preventible. It should not go forth in a sweeping way that they, as an Institute, considered that accidents from falls were always preventible; accidents from falls were in many cases not preventible. No matter how good the roof might be, there would be constant accidents from falls, which no light would be able to protect the miner from. The most perfect lamp would not materially diminish the accidents from falls, although it might do so slightly.

Mr. SWAN said he did not intend at all to convey that he regarded accidents arising from falls from the roof and sides as altogether preventible; but they were to a certain extent, and in some degree—perhaps a small degree—preventible; and he expressed this opinion on the strength of what he saw stated by expert engineers, in the evidence given before the Royal Commission which recently inquired into the causes of accidents in mines. He thought that the almost unanimous opinion of the gentlemen who gave evidence on this point was, that where the light was better, this class of accident was diminished. As to the remarks of Mr. Blackett about the difference between the ordinary lamp and the electric lamp in regard to indicating the presence of gas, Mr. Blackett had pointed out correctly, that in the case of the ordinary safety-lamp the indication of gas was automatic, and that in the case of the electric lamp a test had to be specially made. It was not denied that there was this difference between the two lamps. He assumed—he did not know whether correctly or not—that the examination for the presence of gas would be made by

the overman or deputy, and that the observations by men with lamps when working would not be the sole thing depended upon, or rather that this would not be depended upon to any great extent. He believed the ordinary miner's lamp was not very sensitive as an indicator of gas, and that, therefore, special lamps had to be used for that purpose.

The PRESIDENT said Mr. Swan had not read the motto of the Mining Institute, which says the safety-lamp both warns and preserves. There is no doubt whatever that it would be a good exchange to have a lamp absolutely free from danger in the presence of fire-damp, even if that arising from the presence of carbonic acid was increased.

Professor MERIVALE believed Mr. Swan's contention was, that the ordinary lamp would not indicate a very small percentage of gas.

Mr. SWAN—That is so ; and that, by means of the electrical detector, a very much smaller amount of gas can be detected, and, what is more, measured as well.

The PRESIDENT—That is very important.

A vote of thanks was passed to Mr. Swan for his kindness in attending the discussion.

CONFERENCE OF THE DELEGATES OF CORRESPONDING SOCIETIES, HELD DURING THE MEETING OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, AT BIRMINGHAM, SEPTEMBER, 1886.

In May, 1885, correspondence was going on between the British Association and the Institute, which ended in the Institute becoming a Corresponding Society of the former Association; and in July, 1886, Professor Lebour was appointed to represent the Institute at the Birmingham meeting. This gentleman attended the meeting, and reports as follows:—

Mining Institute, Newcastle-upon-Tyne,
25th November, 1886.

Mr. Chairman and Gentlemen,—Having had the honour of being appointed as delegate from this Institute to the meeting of the British Association, held at Birmingham in September last, I beg to present a report of my proceedings in that capacity.

I arrived at Birmingham on Tuesday the 31st August, and remained till Friday the 10th September. During that time meetings of two kinds were held by the Delegates of the Corresponding Societies—the first being conferences between the Delegates and the Corresponding Societies' Committee of the British Association; and the second, less formal and more frequent gatherings among the Delegates themselves. A proof of the report of the conferences is appended to this communication, and in it will be found a fairly correct account of the part taken by me at these meetings. As regards the less formal meetings among Delegates, I cannot give such elaborate minutes; but I will venture the opinion that the more valuable work done by the Delegates of Corresponding Societies will be found in time to be that done there, than that done at the more formal conferences.

As a general result, I may state that the Corresponding Societies of the British Association—thanks to the new rules under which they now work—have it in their power, for the first time, to powerfully influence the Association whenever they are unanimous as to the advisability of any measure. Each Delegate is not only *ex officio* a member of the General Committee of the Association, but is also (since last September only) *ex officio* a member of the Sectional Committees in the subjects of which the Society he represents is interested.

It has now been clearly understood, as between the Association and the Delegates of Corresponding Societies, that the suggestion of subjects for special investigation is henceforth to form one of the principal functions of the latter; and it is in this sense that the connexion between this Institute and the Association is likely to prove useful to us. The Institute and kindred societies may start subjects of investigation requiring many observers, much money, and combined action: through their Delegates they can get the object they aim at discussed, and, if possible, adopted, by the whole body

of the representatives of the Corresponding Societies, whose unanimous recommendation, to say nothing of their personal votes on the Committees, both Sectional and General, is practically certain to receive the sanction of the authorities of the Association. With this sanction the co-operation of a great many workers might be obtained in Britain and elsewhere, who would in many cases otherwise either not know of the investigation or of the necessity for combined action in its prosecution.

The appended printed documents will show the ground covered by the Association committees of this year.

I have the honour to be, Mr. Chairman and Gentlemen, yours very faithfully,

G. A. Lebour.

The proceedings of the Conference of Delegates of Corresponding Societies, so far as they relate to this Institute, are as follows :—

On Sept. 4.—Professor Lebour stated that many of the local societies, such as the North of England Institute, which he represented, were composed of engineers connected with large works, who might make useful investigations which would be facilitated if backed up by the authority of the British Association. For this reason he hoped that other subjects besides natural history, geology, or anthropology would be recognised at the conferences.

At the Second Conference, on Sept. 7, Professor Lebour further stated :—

That for some time past the North of England Institute of Mining and Mechanical Engineers had had a committee actively engaged on the subject of earth-tremors and their possible connection with mine explosions. This subject was naturally related to those of Sections A, C, and G of the British Association, and its investigation might be powerfully promoted by them. Some of the Corresponding Societies might aid greatly in making and recording observations on earth-tremors in various parts of the country. The more extensive the area over which such observations were made (if by competent observers and with suitable instruments) the more valuable they become; but it was very important that there should be some general understanding between the observers in different parts of the country in order that some degree of that uniformity which is so desirable in matters of this kind should be attained. The cost of the expensive instruments necessary would be much lessened if large numbers of them were used. The question of earth-tremor observations was only one of many in which the engineering societies and the British Association could be mutually useful, the former carrying out the work and the latter lending the influence of its official recognition and support.

The Rev. J. M. Mello (Chesterfield and Midland Counties Institution of Engineers) stated that colliery proprietors were generally unwilling to spend money in investigations unless some very specific form of inquiry was circulated.

Mr. Hopkinson (Hertfordshire Natural History Society) remarked that Corresponding Societies, if supplied with the necessary forms, would no doubt be willing to circulate them among their members.

Mr. Heywood (Cardiff Naturalists' Society) thought the suggestion of observing and recording earth-tremors a most valuable one, and he remarked that the Cardiff Society would be most happy to assist in the investigation, if the formation of a committee was sanctioned by the Association.

In conclusion, Professor Lebour remarked to the Council (held on Nov. 27) that, as the matter now stands, the societies who send delegates have now a very much better position than formerly. For the first time

the societies are recognised not only as bodies instructed by the Association as to what they should do, but as bodies who tell the Association what to do, and they have had such power given them that the moment they are unanimous they can practically carry anything. It would be very useful if in the course of the year this Institute could think of subjects which could not be well done otherwise than by co-operation, so that at the next Association meeting the delegate might be prepared with subjects to suggest.

The list of the committees on special subjects appointed by the Association, and with many of which the Institute members could co-operate, was appended to Professor Lebour's Report.*

* This list will be found in the Annual Report of the British Association for the year 1886.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, FEBRUARY 12TH, 1887.

MR. JOHN MARLEY IN THE CHAIR.

The CHAIRMAN said that Sir Lowthian Bell, President, had been in attendance at the meeting of the Council, but had been obliged to leave in order to attend a meeting convened by the Duke of Northumberland, in connection with the Imperial and Colonial Institute, proposed to be established in London.

The SECRETARY read the minutes of the last meeting and reported the Proceedings of the Council.

The following gentlemen were elected, having been previously nominated:—

ORDINARY MEMBER—

Mr. THOS. VARTY, Skelton Park Mines, Skelton, R.S.O., Yorkshire.

ASSOCIATE MEMBERS—

Mr. HENRY SLADE CHILDE, Wakefield.

Mr. WM. HOLT WAIN, Podmore Hall Collieries, Newcastle-under-Lyne.

STUDENT—

Mr. THOMAS FUTERS, 97, Stanhope Street, Newcastle-on-Tyne.

The following were nominated for election:—

ORDINARY MEMBER—

Mr. WILLIAM GALLOWAY, Mining Engineer, Cardiff.

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MR. S. AGNIEL, Mines de Vicoigne (Nord) Nœux, (P. de C.), France.

Mr. T. F. HEDLEY, Junr., Sunderland.

Mr. A. L. STEAVENSON read the following paper on "The System of Working Ironstone at Lumpsey by Hydraulic Drills:"—

ON THE SYSTEM OF WORKING IRONSTONE AT LUMPSEY MINES BY HYDRAULIC DRILLS.

By A. L. STEAVENSON.

The members of the Institute have twice honoured the works at Lumpsey with a visit, first in September, 1881, when the younger members had an opportunity of seeing the process of sinking the shafts, and afterwards in July, 1886, when they were shown the process of getting the ironstone by means of a hydraulic drill, but as this drill was not described in the Transactions, it has been thought that a detailed account of it would be acceptable to the members.

The ironstone at Lumpsey was reached on the 3rd of November, 1881, after tubbing off feeders amounting to 1,700 gallons per minute; since that date the winding engines, two 42 inch cylinders with scroll drum, by Messrs. Fowler, have been erected and put to work, other surface arrangements have also been completed, and the mine has steadily but slowly progressed, slowly because trade has never allowed the amount of work to be carried on that the arrangements are equal to.

On the occasion of the previous visit the members were shown the Walker drills working by compressed air at Park pit, and drawings of this excellent drill will be found in Vol. XXXI., p. 114; so that on opening this mine the question of mechanical drilling was approached with some amount of experience, and careful estimates were made for applying the Walker system to Lumpsey. This of course necessitated the erection of compressing machinery, which, on a permanent scale suited to a large mine such as this, involved a serious expenditure, so that in September, 1883, the writer reported to Messrs. Bell Bros. that it had occurred to him to utilise the water behind the tubbing; first, because it would save all the outlay for compressing machinery, throw but small additional work on a pumping engine which was only employed three or four hours every day, and at the same time allow of the application of hydraulic power, which is much more economical than compressed air. In this mine it is particularly applicable, because,

as the great bulk of the ironstone is to the rise of the pit bottom, in working to the dip, the water could be run back to the shaft through exhaust or delivery pipes, if necessary. Being aware that a very excellent turbine was made by Messrs. Gilkes & Co., of Kendal, plans and specifications were prepared by Mr. Clough, of Page Bank Colliery, and the writer, and Messrs. Gilkes were asked to tender for the whole machine, with results which have been in every way satisfactory to the present day.

A range of 6 inch pipes is connected with the tubbing at the depth of 50 fathoms, and carried to the bottom of the upcast shaft, and from there into the working face; the size of pipes being, of course, diminished when they branch off from the main, so that the final lengths are only 3 inches, and to these are connected hose pipes of special strength.

The pressure of water at the pit bottom is 215 lbs. per square inch, showing that the full head of 500 feet is made available, and this corresponds with the point in the strata 13 fathoms from the surface, where water was first met with (see strata account, Vol. XXXI., page 113).

DESCRIPTION.

Views of the machine are given in Plates IX., X., and XI., and the same letters correspond to the same parts on all, viz. :—*a a* is a wrought iron bogey, the wheels of which can be secured by brakes 1, 2, worked by a wheel and handle 5, a screw 4, and a lever 3. The water is let in to the back part of the bogey, through the flexible pipe p^1 and the shut-off cock a^1, it is then carried into the centre of the bogey through the pipe b^1, and turning upwards it is secured by a stuffing box and hydraulic leathers c^1 attached to the bottom of a cast-iron cylindrical upright *c* of considerable strength; this upright is firmly secured to the bogey by a clamp *b b*, while at the same time it allows it to have a rotating motion round its axis, which is communicated to it by the attendant, by means of the ratchet brace *d*, the small worm d^1, and the worm wheel d^2, which latter is firmly keyed on to the upright *c*; *f* is a cast-iron semi-circular worm wheel working on a pin f^1 made hollow, so as to allow of a connection being made by means of the small pipe e^1 provided with suitable stuffing boxes to allow of its free motion round the axle f^1. The upper portion of the semi-circular wheel is hollow and allows a wrought iron tube *e* to pass through it; the portion of this tube which is enclosed within the semi-circular wheel has a number of small holes which allow the water coming through e^1 into the hollow portion of the semi-circular wheel to pass through into the tube.

The semi-circular worm wheel *f* is moved round its axis f^1 by means of a worm f^2 and the ratchet brace f^3.

The tube e can also be made to rotate by means of the worm wheel g, the worm g^1, and the ratchet brace g^2.

There is a stop-cock h^1 at one extremity of the pipe through which the water is admitted into the turbine $h\,h$, where, after it has performed its work, it is allowed to escape through the pipe s. The whole length of boring bar proper p is screwed and cut with a key way, which allows it to slide backwards and forwards on a key inserted in the socket l^1, which is cast on to the bevelled wheel l; this socket is not screwed but rides on the tops of the threads on the bar p, and rotates freely with the bar p in two uprights $y\ y^1$ attached to the top of the turbine $h\,h$. The upright y^1 has inserted into it a small bush n, made with a small groove in it at one end so formed as to keep a nut o in its place; this nut o allows the screw on p to work in it, and is split so that it can be opened out by a simple contrivance o^1, and allow the bar p to be pushed freely backwards and forwards when adjusting the drill t to its work, or to enable the attendant to pull it back quickly after the hole has been drilled. Motion is given to the nut o so that a suitable speed may be given to the drill by means of a train of small wheels m^1 to m^3; m is keyed on to the socket coat on the bevelled wheel l, and m^1 and m^2 are fixed on to a small spindle x, working in the upright y^1, m^3 being keyed to bush n and nut o bolted to m^3 with one fixed bolt for a hinge and the other pin o^1 for drawing out to open the nut with the hand; q is a universal joint connecting the drill t to the bar p. The whole of the bar p and its driving apparatus can be made to turn round to any position by slackening the bolt j which secures the ring i to the ring i^1, to which latter are attached the two uprights $y\ y^1$, and then tightening it when the requisite position is obtained; u is a wheel attached to a spindle passing through the bogey a, carrying at its lower end a small bevelled pinion geared into the bevelled wheel u^1, which allows the position of the bogey to be readily adjusted by the attendant.

From this description it will be seen that the position of the drill with reference to the part of the stone it is desired to pierce may be adjusted by four different movements.

First, round a vertical axis by the worm wheel d, fixed on the main upright c.

Secondly, round a horizontal axis by the sector f.

Thirdly, round the axis of the hollow arm e by the worm wheel g.

And fourthly, by the adjustment j on the top of the turbine h, which allows the drill to assume any desirable angle with the bar e; and it will be seen that the machine has been specially designed so as to enable one

drill to be quickly set to any position either at the top or bottom of the seam by means of one attendant, who has all the handles necessary to enable him to do so within his reach without his having to move, and to fix and hold the drill rigidly when once set, by means of a system of worm wheels, instead of trusting to clamping smooth plates or surfaces as is commonly practised, which surfaces, by slipping constantly, allow the drill to get out of line and work to a great disadvantage, frequent stoppages being the result. All these objects have been most successfully accomplished.

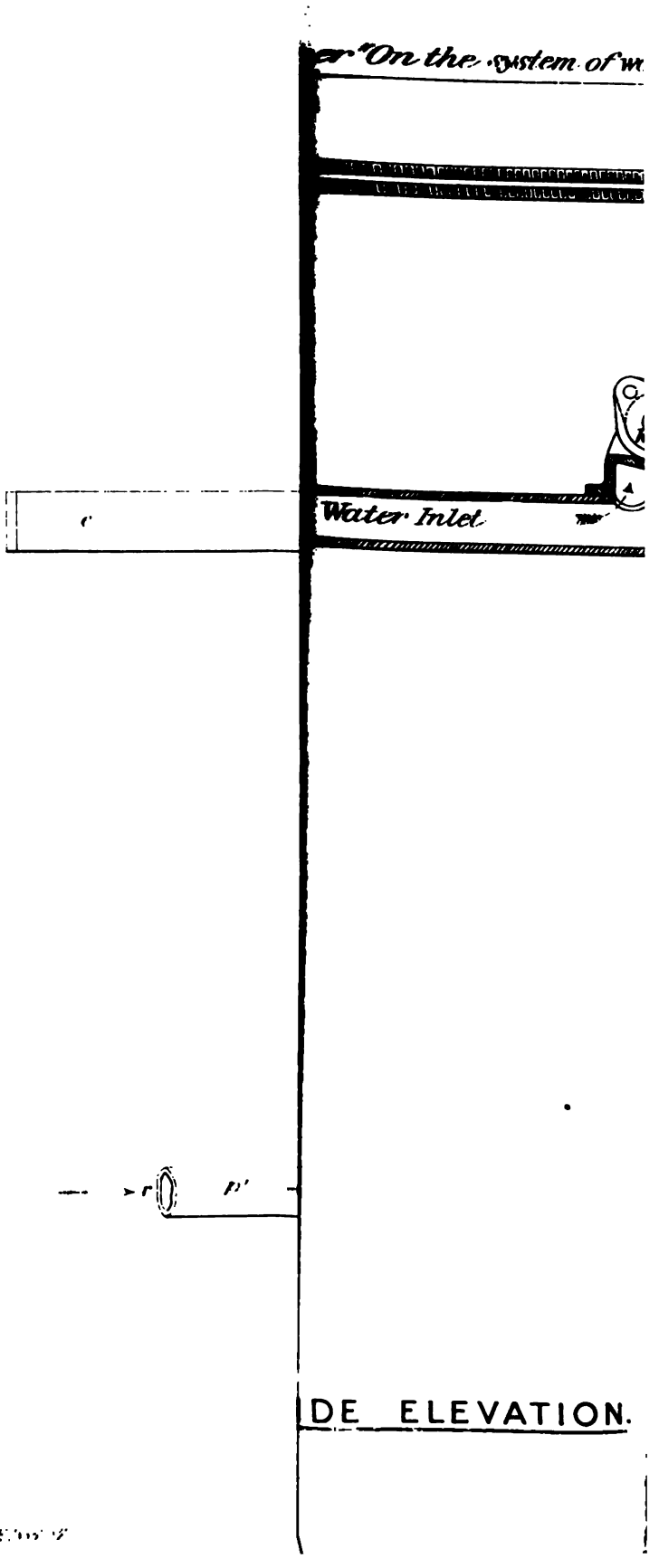
The work it has done may be thus described: the first machine commenced on the 9th October, 1884; during the first quarter it averaged 55·4 holes per shift of eight hours, producing 125·3 tons each shift and 2·26 tons per hole, the cost for powder being 2·66d. per ton of ironstone, compared with 1·83 per ton by hand. Since that time the work done has materially improved, so that during the quarter ending 9th October, 1886, it averaged over 152 tons per shift.

On various occasions special tests have been made with the machine, but for the purposes of this paper Mr. Dixon has been kind enough to make the following observations:—"I have to-day carefully timed the No. 2 Drilling Machine and measured the water, and find it drilling at the rate of 2 feet 5 inches per minute. The water consumed is 31 gallons in 28 seconds, equal to 66·4 gallons per minute when running. The machine took 79 minutes to drill 17 holes, measuring in all 76 feet 3 inches in one bord, or nearly one foot per minute, including setting the machine and changing the drills. Supposing that 55 holes are drilled about 7,000 gallons of water are used per day, which we can pump easily in twenty minutes." This equals 5 gallons per minute, day and night.

The repairs to the machine have been practically nothing, but frequent alterations and improvements have suggested themselves during the experience gained in nine months; three hoses had cost about £9, when the members visited Lumpsey, but one was then as good as new and the two others not worn out; the total stores used during nine months amounted to a few shillings over £20.

Of the value of mechanical drilling, as compared with hand mining, there remains no longer any dispute: one skilled man and an assistant work the machine eight hours per day, and following them is a shot firer, but he cannot charge and fire the holes fast enough to keep up with the machine without assistance, and then a gang of unskilled men break and fill the stone into waggons.

The cost of drilling the holes being small, the system of blasting is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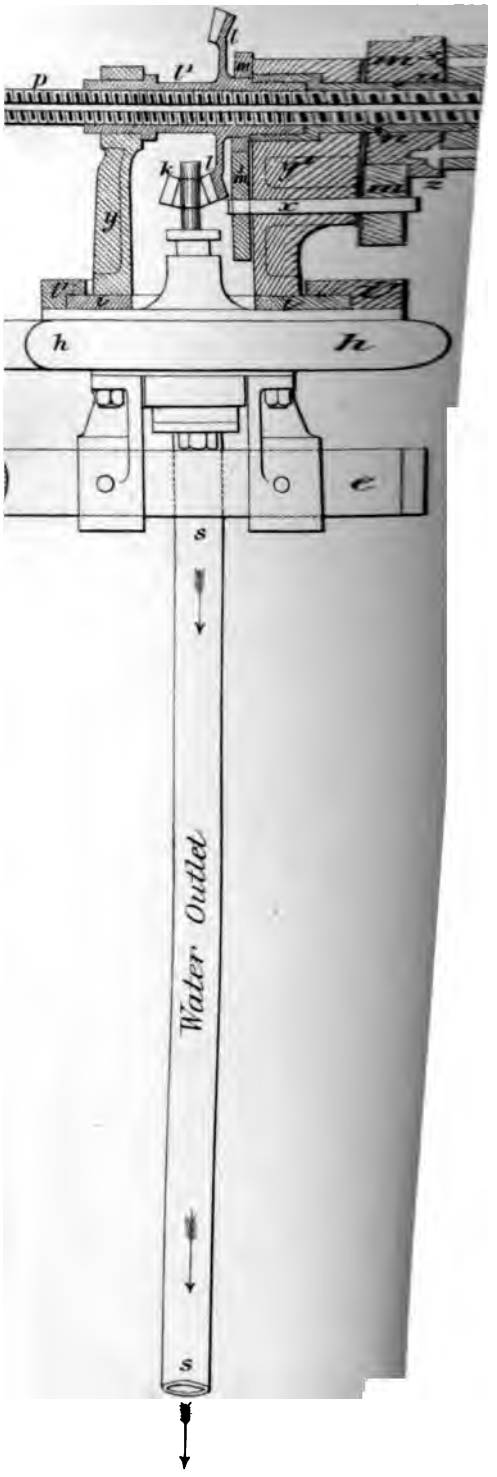
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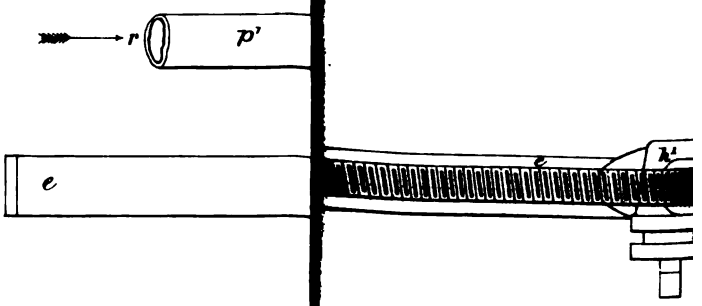

PLAN.

Scale 1" = 1 Foot.

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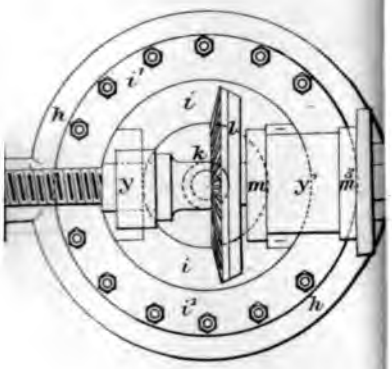
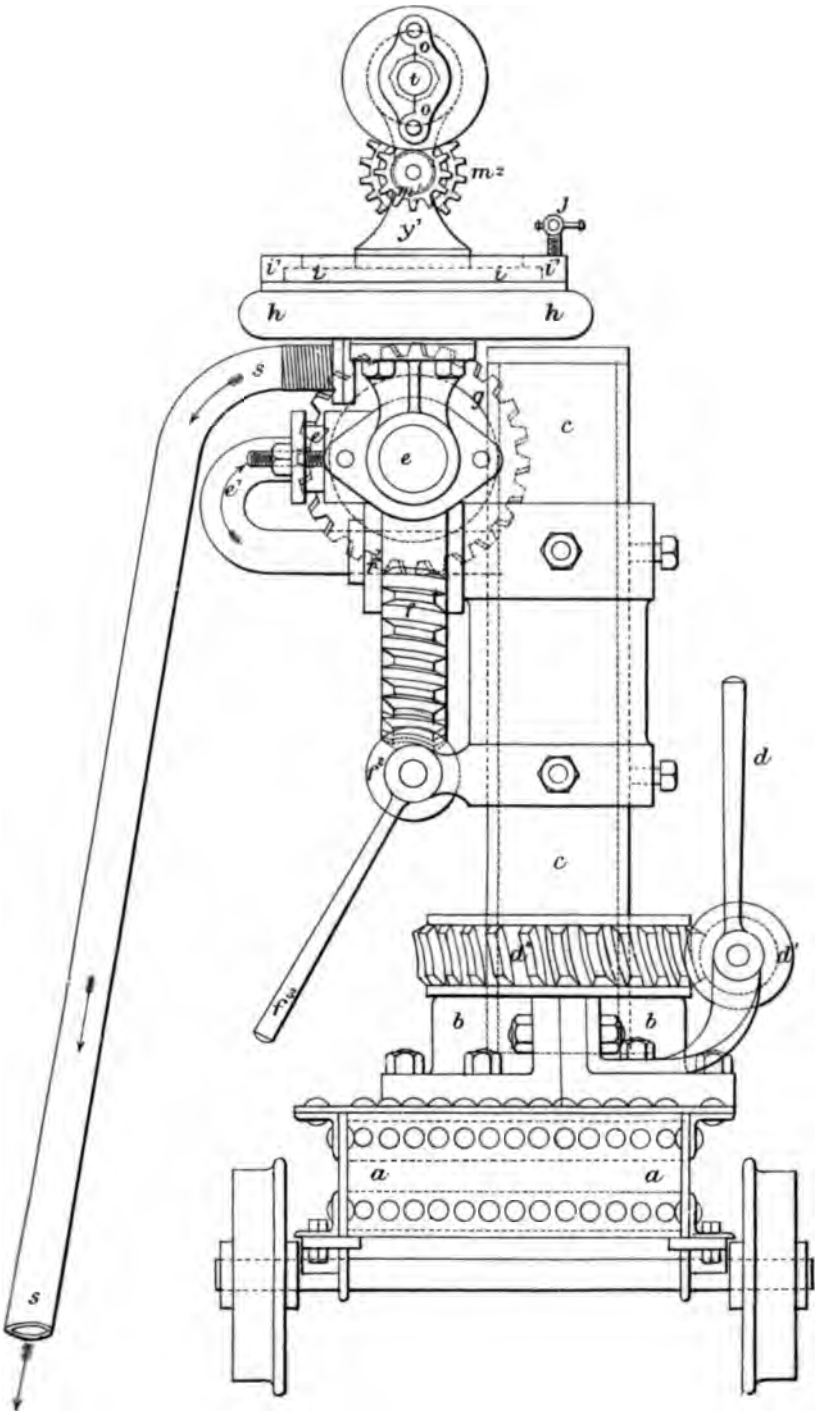


To illustrate M.r A.L.Steavenson's paper "On the system of working Iron Stone at Lumpsey Mines by Hydraulic Drills."



END ELEVATION

Scale 1" – 1 Foot.

Andr. Reid, Lith. Newcastle.

entirely altered so that forty tons of loose stones are often left in a single place. The cost of powder per ton of stone is higher, but this is amply covered by the saving in labour.

The writer has been often asked about the suitability of the drill for other districts and harder stone; but the rotary drill will not face a harder stone than that of Cleveland, although by the adoption of a small crown similar to what is used for the diamond boring machines no doubt this could be got over, and by modifying the mechanical arrangements a reciprocating or jumping action could be imparted.

Another point which should not be lost sight of is that although the water pressure in this case is got from a natural supply, nothing could be more simple or cheap than a force-pump to supply water at any pressure thought desirable, which arrangement would certainly possess many advantages over any system actuated by compressed air; for the loss incidental to the heating of air when under compression and the large size of pipes requisite, as well as the large and unavoidable leakage form very formidable drawbacks (as the writer has had ample means of ascertaining) which do not accompany the use of water.

Perhaps, in these days of anxiety as to the future of powder in dusty collieries, the writer may be allowed to say that he has not yet seen any means of mechanical drilling likely to supersede hand labour either for coal or stone; the holes in coal are so few and far between, that no margin is left to cover the outlay and loss of time incidental to moving about from place to place, although whether for water-cartridges, or wedges, the size of the holes in future is likely to be much greater than in the past.

The CHAIRMAN said they would be glad to hear any remarks upon the paper.

Professor MERIVALE said, he would like to ask one or two questions, but he did not propose to make any remarks upon the paper. How did Mr. Steavenson get the water back when working to the dip? How many pounds of powder did he use to the ton of ironstone? Was it of very great importance to get large pieces of ironstone as in the case of coal? And how did Mr. Steavenson measure the water used?

Mr. STEAVENSON said, that with respect to getting the water from the dip, he would simply run the water back to the bottom of the pit in a pipe. He thought he had already stated that about 6 ozs. of powder were used to one ton of ironstone on an average in Cleveland. In Bell

Brothers' mines alone somewhere about a ton of powder was used every day when in full work. Large blocks were no benefit, but rather a drawback; for these had to be reduced to the size suitable for calcining. He had tested the mode of measuring water over a weir or notch, and with a box, and his experience certainly was that, in measuring water over a notch, a less quantity was given than was obtained by actual measurement with a cistern.

Mr. T. W. BENSON asked whether this mode of working a drill would be any advantage in driving a stone drift in hard rock; or whether Mr. Steavenson considered it would be necessary to use a percussive drill for this class of rock?

Mr. STEAVENSON said he had already stated that rotatory drills were not suited for any hard stone; but it would not be a difficult matter to alter the movement from the rotative to the percussive action, or a small diamond drill could be substituted for the auger. He believed a percussive action was absolutely necessary for a hard stone.

Mr. C. Z. BUNNING asked Mr. Steavenson if he had had any experience with the Brandt drill? It is a rotatory hydraulic drill, and was used in boring the Arlberg tunnel in Germany, and did exceedingly good work.

Mr. STEAVENSON stated that although he had used a great many drills, both revolving and jumping, he had not to his knowledge had any experience with the German one spoken of. His experience conclusively pointed out that a jumping drill was absolutely necessary for hard stone, except with the Diamond drill.

The CHAIRMAN said he had not only the duty, but the great pleasure of proposing a vote of thanks to Mr. Steavenson for his paper.

Mr. J. B. SIMPSON seconded the vote of thanks, and it was unanimously agreed to.

The following paper on "A Fire-damp Indicator," by Sir William Thomas Lewis and Mr. A. H. Maurice, was read:—

A FIRE-DAMP INDICATOR.

By Sir WM. THOS. LEWIS and A. H. MAURICE.

The principle on which the instrument is based is very simple. Metallic platinum, heated to redness, has the property of burning carburetted hydrogen gas when mixed with atmospheric air in even the minutest proportion. The reaction is peculiar, and differs somewhat from ordinary combustion, though the effect is practically the same. When the platinum attains a temperature which may be termed a barely visible red heat it acts upon carburetted hydrogen gas, decomposing it and condensing the hydrogen on the surface of the metal, and at the same time it in like manner condenses oxygen from the intermixed air, the atoms of the two gases being thus brought into such close proximity that they combine chemically, forming water, which is dissipated as vapour. The nascent carbon set free from the hydrogen enters into combination with another portion of the oxygen of the air, forming carbonic acid gas. These two products of the reaction, together with the remainder of the air, occupy less bulk or space than was occupied by the original mixture of air and gas, so that if the process takes place in a closed vessel there is a partial vacuum formed within it. Unless present in explosive proportions the gas, although it is in effect burnt, is not really ignited, which is the case in ordinary combustion, the temperature necessary for ignition being far in excess of that required to insure the action of the platinum.

Taking advantage of this property of metallic platinum, this instrument is arranged that the mine air to be tested shall be enclosed in a small air-tight chamber, in which is fixed a fine platinum wire, forming part of a battery circuit, so that on passing a current of electricity the wire may be brought up to the required temperature. To ascertain the difference in density in the enclosed air after the gas has been destroyed a glycerine gauge of peculiar construction is used, which is capable, by means of the attached scale, of showing the degree of vacuum caused by the burning-out process in the air-chamber, and which in effect represents the amount of gas that was present.

The indicator consists essentially of the air-chamber *a* (Plate XII.), containing about 2 cubic inches of air; the gauge *t*, with an ivory scale attached to its upper limb, graduated to read to $\frac{1}{4}$ per cent. of gas; and the platinum wire *p*, which is about $\frac{3}{4}$ inch in length, and No. 30 B.W.G. (It will be observed that the upper limbs of the gauge are protected by a light brass shield *s*.) The bottom of the air-chamber consists of a brass cap, fitted with a leather washer, which screws on perfectly airtight. It is removed to admit mine air, which will itself fill the air-chamber in an air-current, but in a stagnant atmosphere, or in fall holes overhead, a slight backward and forward movement of the hand is sufficient to fill it with the air to be tested, the instrument being in each case held on its side (*i.e.*, horizontally).

The air-chamber being of brass it is necessary that the battery connections should be insulated at the points *i i*, where they pass through the side of the instrument.

The gauge, which is the most important portion of the instrument, may be described by reference to the diagram. *g* is a small glass cylinder, 2 inches in length by ·8 inch in diameter, closed at each end with brass caps cemented on. Through the upper end a small tube *t* enters the cylinder *g* and extends downwards to within ·05 inch of the bottom. This tube rises vertically to a height of about 7 inches, and is then bent back and descends into the air-chamber *a*, within which it terminates. The lower portion of the gauge glass *g* is filled with coloured glycerine to a height of half an inch, the upper portion being filled with air, which is under sufficient pressure to keep the liquid standing about half way up the glass tube *t*. The sectional area of cylinder *g* is thirty times greater than that of the tube *t*, so that if the air in *g* expands one-thirtieth of an inch the displaced liquid will rise 1 inch in the tube *t*. The height of the air column in the cylinder *g* being $1\frac{1}{2}$ inches, if it expands 1 per cent. of its volume it will displace the liquid to an equal extent, *i.e.*, to 1 per cent. of 1·5 inch = ·015 inch, and cause it to rise ·015 × 30 = ·45 inch, or, to be quite correct, ·4 inch, as allowance has to be made for the back pressure due to the weight of the liquid in the tube *t*. It is thus seen that when the normal pressure of the air in the air-chamber *a* is reduced by 1 per cent., as it would be by burning out 1 per cent. of gas, the confined air in *g* expands 1 per cent., and the liquid rises ·4 inch in the tube *t*. This gauge, therefore, affords an accurate means of measuring the amount of vacuum formed in the air-chamber *a* by burning out the gas. The graduation of the scale is made by calculation checked by actual trial. There is a pointer or index

finger attached to the scale, which is made to slide up and down, and the use of which will be explained later.

The air in the air-chamber becomes heated by the platinum wire while the test is being made, and expanding would tend to depress the liquid in the gauge ; for this reason it is necessary that the glass cylinder *g*, consisting of the lower portion of the gauge, should be placed within the air-chamber to bring its enclosed air under the same heating influence. Thus the air in the gauge and the air in the air-chamber expand equally by increase of temperature, and the effect on the gauge is *nil*.

When, however, the air-chamber is opened by removing the bottom cap the gauge is free to act as a thermometer, and hence the tube *l* is of greater length than might otherwise have been necessary.

The battery which it is proposed to use with the indicator will be circular, and about 6 inches in diameter and $2\frac{1}{2}$ inches wide, and will be carried slung over the shoulder by a strap. When it is required to make a test the indicator is hooked on to the battery, which, by turning a handle, is brought into action. As it is necessary that the duration of the current should be accurately timed, this will be regulated by a simple automatic clockwork arrangement attached to the battery to cut off the current at the expiration of the required time.

It requires a considerable period to burn out the whole of the gas in even a small air-chamber. Nearly two minutes are required for the one shown in the drawing. An air-chamber of a given size always requires the same time to completely burn the gas whatever the percentage may be and whatever the battery power applied ; and it is found from repeated experiments that the gas is invariably burnt at a constant and uniform rate. The results of these trials being plotted to scale an indicated diagram was obtained represented by an elliptic curve, the ordinates of the curve representing the proportion of the gas burned and the major-semi-axis the time required to burn out all the gas. Having once proved this it was easy to arrange to cut off the battery at any given time, the corresponding ordinate giving the proportion of gas burnt in that time, from which the actual quantity present is readily calculated. To simplify the matter the cut off was made at ·13 of the full time required to burn out the whole of the gas, whatever that may prove by experiment to be. At ·13 of the full time, 50 per cent. (or one-half) of the quantity of gas is invariably found to be destroyed, and the gauge would then register half the percentage present ; but by arranging the graduation of the scale accordingly, the gauge is made to show the full quantity of gas when

only half has been burnt out. Taking the time required to burn all the gas in the air-chamber, viz., 110 seconds, and multiplying it by ·13, it gives 14 seconds as the time required for an indication of half the gas; and from actual trials this proves to be absolutely correct.

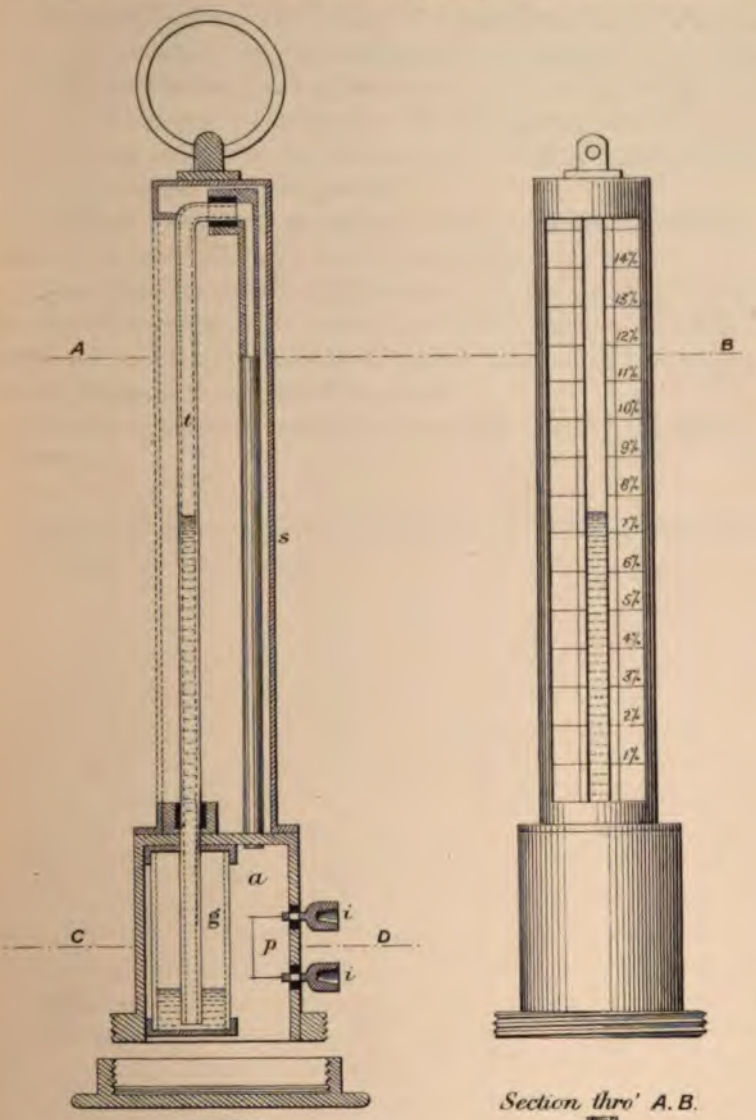
To make a test with the indicator the cap is unscrewed from the bottom of the air-chamber, and the instrument being held on its side, with the open end facing the air-current, the air to be tested enters and fills it; or if out of a current, or overhead, it is held in the same position and moved to and fro two or three times. The cap is then screwed on, and the index finger slipped along the scale till it is level with the top of the liquid in the gauge glass. The indicator is now hooked on to the battery, and the current is passed for 14 seconds. If any gas is present the gauge will show by the liquid rising above the index finger the exact percentage, which may be read off at once from the scale. In practice the scale is graduated to read $\frac{1}{4}$ per cent. of gas, but if required a very much smaller percentage may be indicated.

The CHAIRMAN said they would be glad to hear any remarks upon the subject. Perhaps Professor Bedson would make a few remarks.

Professor BEDSON said he really had no special knowledge of the paper except that which he had gleaned by hearing it read; therefore he had no remarks to make. He might, however, mention that it was an interesting contribution to the study of the combustion of marsh gas or fire-damp when mixed with air, and he considered that the authors had established the fact that they could completely burn so small a quantity of marsh gas; and they had further established that it required a very considerable time to effect that combustion. He also thought that the writers, who had evidently taken great pains in working out the practical details, had thrown considerable light on this class of indicator, which had been sketched out in a communication from Mr. Swan, and had proved that indications of an extremely small percentage of gas could be obtained. He had no idea of the practical value of such an indicator; he left that to other hands.

Mr. THEO. WOOD BUNNING said he thought that Professor Bedson would agree with him that this indicator is precisely similar in its principle to that described by Mr. Swan. The only question is whether, this being a larger instrument than Mr. Swan's, it was not more likely to give a truer indication of the state of gas in a pit.

To illustrate the paper "On a New Fire damp Indicator" by Sir Wm Thomas Lewis & Mr A.H. Maurice.



Section thro' A.B.

Section thro' C.D.

Scale – $\frac{1}{2}$ full size.

Professor BEDSON—The principle is exactly the same. The only point in connection with the instrument now described is, that these details have been worked out in a way which, so far as he knew, Mr. Swan had not as yet attempted. He need scarcely add that a knowledge of these details was absolutely essential in order that the instrument might be used as a reliable indicator.

Professor LEBOUR suggested that the instrument itself should be exhibited at a meeting before the paper was discussed.

The CHAIRMAN said that, if possible, arrangements would be made for one of the writers to be present at a future meeting to give explanations, and to have the instrument here for examination. He moved a vote of thanks to the authors of the paper.

Professor MERIVALE seconded the resolution, which was agreed to unanimously.

The following paper, by Mr. S. B. Coxon, on "Securite, a new Blasting Compound," was read :—

ON "SECURITE," A NEW BLASTING COMPOUND.

By S. B. COXON.

This is a German invention for a safe, cheap, and efficient blasting powder, made out of the bye-products of coke ovens and gas works. It is, weight for weight, more powerful than gun cotton, blasting gelatine, or any other known explosive, and is 35 per cent. cheaper than dynamite.

The most important advantage claimed by its use is the absolute power which it possesses of destroying all flame and sparks within the range of the products of its combustion, so that, in point of fact, it provides in its composition all the advantages sought to be secured by water cartridges. These remarks will become apparent by careful study of the elements of which it is composed and the form they assume after explosion.

There are four variations in the mode of preparing this powder, and supposing that complete combustion is to take place, the following equations will represent the proportion by weight in which the materials should be mixed, and the products which would be formed after explosion :—

1st. Dinitrobenzene, $C_6H_4(NO_2)_2$ mixed with ammonium nitrate, as follows :—$10(NH_4NO_3)$, which when exploded gives $22H_2O + 11N_2 + 6CO_2$, or 44 volumes of steam, 22 volumes of nitrogen, and 12 of carbon dioxide.

2nd. Trinitrobenzene, $2C_6H_3(NO_2)_3$, mixed with ammonium nitrate, as follows :—$15NH_4NO_3$, which when exploded gives $33H_2O + 18N_2 + 12CO_2$, or 66 volumes of steam, 36 volumes of nitrogen, and 24 of carbon dioxide.

3rd. Dinitronaphthalene, $C_{10}H_6(NO_2)_2$, mixed with ammonium nitrate as follows :—$19NH_4NO_3$, which, when exploded, gives $41H_2O + 20N_2 + 10CO_2$, or 82 volumes of steam, 40 volumes of nitrogen, and 20 of carbon dioxide.

4th. Trinitronapthalene, $2C_{10}H_5(NO_2)_3$, mixed with ammonium nitrate as follows :—$33NH_4NO_3$, which, when exploded, gives $71H_2O + 36N_2 + 20CO_2$, or 142 volumes of steam, 72 of nitrogen, and 40 of carbon dioxide.

The whole of these products of combustion act simply as diluents of the oxygen in the air, but are otherwise possessed of no deleterious properties.

These substances are mixed in a solid granular condition, as easy to manipulate as ordinary powder, and exercise no chemical re-action upon each other. They cannot be exploded by red heat or flame, but only by a strong detonating cap, they are not affected by atmospheric influences, and do not ignite fire-damp or air charged with coal dust.

In preparing the said compound it is preferred to use dinitronaphthalene which is prepared in the known manner by boiling one part by weight of pure napthalene with three parts of nitric acid of 40 per cent., the boiling being continued until all naphthalene has been precipitated. This substance, after being freed from excess of acid by washing, is then mixed with ammonium nitrate in the proportion of 218 parts by weight of the former to 720 parts by weight of the latter. This compound (No. 1) requires however for its explosion very strong detonating caps. In order to obviate this inconvenience in certain cases, there may be substituted for the dinitronaphthalene, two parts of dinitrobenzole, prepared in the known manner by the action of concentrated nitric acid upon a benzole of 81° cent. boiling point. This substance is mixed with five parts of ammonium nitrate (compound No. 2), and to this is added 25 per cent. of compound No. 1. The substances are all incorporated in a dry granular condition.

In order to protect these compounds against moisture and to increase their durability, they are mixed with about 5 per cent. of nitrated resin (fir resin or colophonium) dissolved in alcohol. The nitrated resin is prepared by boiling one part of resin with three parts of nitric acid of 40 per cent., and then washing with hot water.

According to the purpose to which the compound is applied, it may consist either of one or the other of the above described mixtures alone, or of two or more of them mixed together.

Thus if an explosive compound of very crushing effect is required, most is taken off No. 1 ; in that case powerful detonators must be used for firing. Although it is preferred to employ the dinitrobenzole or dinitronaphthalene in preparing the said compound, yet, as above stated, trinitrobenzole or trinitronaphthalene may also be used in lieu thereof.

This explosive compound, termed "Securite," forms a granular powder of 1·6 specific gr. and has the following advantages :—

1.—Its preparation, as also the storing and manipulation thereof, is perfectly safe.

2.—It cannot be exploded by ordinary concussions or blows nor by a burning or a glowing body.

3.—Its use is perfectly safe in fire-damp and air charged with coal-dust.

4.—It breaks down the coal in a similar manner to ordinary powder.

5.—When exploded it yields harmless gases, so that men can work in enclosed spaces immediately after an explosion has taken place therein.

The following is a translation of a Report by Herr Margraf, the Mines Inspector, whose interesting remarks on the experiments made with coal-dust under the direction of the Prussian Government at Saarbrücken appear in Vol. XXXIV. of the Transactions :—

Securite, which has been discovered by Mr. Schoenewez, apothecary, at Dudoreller, is a granulated powder of light yellow colour, with an odour of bitter almonds. Brought into contact with fire, it burns with a yellow flame slowly and without exploding, melting at the same time, and makes but little smoke. The flame is extinguished the moment the contact with fire ceases. It cannot be ignited by any shock or blow to which it might happen to be subjected during its transport or manipulation, for layers spread out upon an anvil could not be made to explode although violently struck with heavy hammers.

Securite can only be exploded with so-called 1,000 gramme caps. The action is like that of Hellofit, about four times as forcible as blasting powder.

Through a great series of tests it has been conclusively proved that Securite is absolutely safe to be used in the presence of fire-damp and coal-dust. Covered with the most dangerous coal-dust and surrounded with ten per cent. of fire-damp, the cartridges on explosion never gave an appearance of flame, nor could any be noticed when the cartridges were saturated with petroleum ether. Experiments were made to satisfy myself how Securite would act in workings if brought into direct contact with a pocket of pure fire-damp. In these the cartridge was covered with the most dangerous description of coal-dust in the presence of ten per cent. of fire-damp. The entire experimental tube was then sprinkled with coal-dust.

Fourteen times this experiment was repeated without showing the slightest appearance of flame. Later on petroleum ether was substituted instead of coal-dust, but no appearance of flame was noticed.

These experiments show conclusively that Securite is absolutely fire-damp proof, and it has also stood the test in collieries in the presence of very dangerous fire-damp mixtures. Once, in an advanced heading in the Carlowitz seam, in the third level of the mine König, which gives out a large quantity of fire-damp, but which is so well ventilated that with electricity dynamite shots could be fired without danger, although each shot ignited the fire-damp in the fissures near the explosion, the ventilating current was stopped and four shots with Securite were fired into the fire-damp mixture, when no ignition followed, and a very serious explosion obviated.

The fall of large coal resulting from the use of Securite is in no way inferior to that of blasting powder. This remark particularly refers to the hard seam in the Saar district. Indeed in very hard seams Securite is by far superior to Carbonit.

The explosive gases of Securite are practically perfectly harmless, more so than those from any other explosive known to me.

In wet holes Securite has to be used in waterproof cartridges.

Securite has proved itself an explosive deserving the most earnest attention. Compared with Carbonit it is decidedly much more fire-damp proof, for experiments made after the report about Carbonit had been published, proved that Carbonit was unreliable.

(Signed) MARGRAF,
MINING INSPECTOR.

Neunkirchen,

Mr. WALTON BROWN asked if any one could explain the exact meaning of the term, 1,000 gramme caps used in the paper, if 1,000 grammes were intended, it meant $2\frac{1}{4}$ pounds of detonator?

The SECRETARY said, it meant a kilogramme of fulminate divided among a thousand caps.

Mr. BIRD said that in the abstract of the paper it was stated "that the products of combustion are entirely composed of substances in which no flame can exist; the explosives are therefore perfectly safe." The same argument would apply to gunpowder, because the products of the explosion in the case of gunpowder were, roughly speaking, carbon dioxide, nitrogen, and sulphide of potash, all of which were inimical to combustion. If the argument was good in the case of securite, it should be equally good in the case of gunpowder; but, unfortunately, they knew it was not. When they had experimented in this country with this new explosive the discussion would be carried on with more profit than it could be now.

Professor BEDSON said, that with regard to the representation of what might take place when securite was exploded, the chemical equations were entirely theoretical. They all knew that, theoretically, gunpowder should give the same gaseous bodies; but as a matter of fact, the experiments of Sir Frederick Abel and Captain Noble have shown that the explosion of gunpowder was really attended by a most complex and complicated series of reactions. No simple equation could really convey what took place in the explosion of gunpowder. The same would also probably be found to be the case if they took all the different explosives recommended in this paper prepared in the proportions by weight recommended by the author. He found, for instance, when dinitronaphthalene is used, it is recommended to take 218 parts by weight of this compound, and 720 parts by weight of ammonium nitrate. Theoretically, 1,620 parts of ammonium nitrate are required for the complete combustion. If they exploded such a mixture as was recommended in powder No. 1 (dinitrobenzene), there would result a complex chemical

action forming compounds which were not so harmless as carbon dioxide, steam, and nitrogen. In all probability they would have gases of the nature of carbon monoxide produced, and other incomplete products of combustion of carbon. As to the "1,000 gramme cap," he thought that it rather related to the power of the cap—the force given out by the explosion of the cap rather than its weight.

Professor MERIVALE said, he agreed with the last two speakers. He should like to know if it was conceivable for such a force as this to be exercised without any heat or flame?

Mr. A. L. STEAVENSON said, the invention which was before them reminded him very much of an explosive brought over from France a short time ago called Panclastite, far more powerful than anything he had ever met with. It occurred to his mind, as was also suggested by Mr. Bird, that, although the results were said to be not dangerous, they could not have an explosion without at the same time producing a temperature sufficient to be dangerous in the presence of gas. He was speaking in the presence of the Professor of Chemistry, and he (Mr. Steavenson) would offer his opinion more as a question than an actual statement. He asked whether it was possible to have an explosion which heated the products of combustion, whatever they might be, even if they were steam, to an enormous temperature—probably 3,000 degs.—without their being in a condition to explode the gas in a mine? They were told by the German report of Herr Margraf, the Inspector of Mines, that "securite is absolutely safe to be used in the presence of fire-damp and coal-dust." But then this gentleman had reported that coal-dust itself was not explosive, a fact which was to the speaker's mind proved beyond all doubt, and therefore he did not put any high value upon his experiments with this explosive. This paper did not actually relate to coal-dust, but he would like to say a word or two upon that subject. Almost all the experiments made with coal-dust were not made under the conditions which prevailed in a colliery when coal-dust had exploded. They knew that in collieries where there was such a large quantity of dust, when it once had attained to ignition point it virtually was under pressure. They all knew the difference between exploded gunpowder in the open, and in a hole under pressure. So it was with coal-dust. If they could explode coal-dust in the condition in which it was in the mine, that is under pressure, they would get a very different result from what the Germans got when they tried coal-dust in a short passage. The Germans experimented with coal-dust in a covered-in drift with only a wagon at the end to move. But take eight or ten tons of coal-dust, blow it up in a confined space, and ignite

that dust—it would burn so rapidly under pressure that it all would go off at once. That was the difference between firing coal-dust in a colliery, and the way the German gentlemen had fired it. As to this new explosive, they were told that it was exceedingly powerful—that it was far more powerful than dynamite. Then it would be no value under general circumstances, because it would only cut the mineral and leave the bulk of it standing, instead of throwing it down. This he had tested and confirmed in practice over and over again. Under all the circumstances he could hardly agree that the new compound would be very valuable as a blasting material. He had often thought of giving a paper on his own experiences with explosives. Whenever any new explosive was invented, they generally brought it to Cleveland, where the consumption was very large, and so during the last 25 years the speaker had tested a very large number of explosives. In 1863 several gentlemen and himself spent a day firing shots and walking about with nitro-glycerine under their arms; and they were not aware of its dangerous character until the then Sheriff of Newcastle and others were accidentally killed by an explosion of this compound a few days after. After that they were very careful.

Mr. BLACKETT asked Professor Bedson whether it was possible, from the fact of ammonium nitrate giving off nitrous oxide when heated, that this gas might be developed by incomplete combustion of securite and whether nitrous oxide was not an intense supporter of combustion?

Professor BEDSON said, he thought nitrous oxide could not be regarded as an explosive gas, although in its preparation from ammonium nitrate the decomposition was occasionally attended by explosions. He did not think that nitrous oxide would be produced in the use of the explosives described in the paper, as the nitrous oxide was the material supplying the oxygen. What was more to be feared was the formation of combustible bodies by the incomplete combustion of the various nitro-compounds used.

Mr. BIRD asked whether nitrous oxide was the result of the explosion? He had heard that nitrous oxide was one of the results of explosion of fire-damp. He had also heard that explorers in northern collieries, after an explosion, had felt the peculiar physiological effects of laughing-gas in the after-damp.

Professor HERSCHEL said that, as to the quantity of heat present after an explosion, and before the expansion of the gases, the question of the violence or power of the explosive depended plainly upon the quantity of that heat, and the work thus stored in the volume of the gases before

they expanded. The chemical and physical determination of the strength of the explosion consists in nothing else but the heat developed. In gunpowder, part of the residue was solid, but it was no doubt at first in a vaporous state. The heat was there from the chemical action which did the work. It might be possible for Professor Bedson to say how much heat of formation the materials contained in their first, and how much in their final states; and the difference between those heats was let loose, by the chemical action, upon the quantity of gases formed. These gases having this heat now became explosive. If the expansive work was greater than that of nitro-glycerine, then there was more heat in them than was set free by the explosion of nitro-glycerine. It was scarcely possible for the author of this paper to contend that securite could be exploded without flame if its explosion was more violent than that of gunpowder or nitro-glycerine. It might be more instantaneous, and more sudden, perhaps.

Mr. MARKHAM—What is the comparative cost between securite and gunpowder in the working of coal and stone?

Mr. C. Z. BUNNING said, it was stated in the paper that this new explosive could not be fired by ordinary concussions or blows; and asked if a slanting blow from a wooden hammer had been tried, such as had been found to explode other, so-called safe compounds?

Professor BEDSON said, it was quite possible to calculate out the heat produced by the complete combustion of these compounds.

Professor HERSCHEL—Theoretically.

Professor BEDSON—Taking the theoretical equations as the data for the calculation. A gramme of the mixture No. 1 would give 1,233 cubic centimetres of gas at 100 degs. centigrade and normal pressure; whereas a gramme of gunpowder gives, according to Abel and Noble's experiments, 382 cubic centimetres under the same conditions. Then, of course, this mixture, No. 1, would have three times the force of gunpowder. Then take No. 3 mixture—supposing complete combustion to result, one gramme of that would give 1,250 cubic centimetres, under the same conditions—that is at 100 degs. centigrade, and 30 inches of mercury.

Mr. THEO. WOOD BUNNING thought the remarks of Mr. Steavenson worthy of serious attention, and that they should be replied to directly by the authors of this paper. There was no doubt that gases without flame of any sort might become sufficiently hot to set fire to other matter. For instance, the air round a steamship chimney in confined places where it was not free to circulate would of itself, without flame or spark, get so

extremely hot as to ignite wood which was in its vicinity. So gases, in themselves inimical to combustion, or even water itself, under certain conditions might get so exceedingly hot that, although they did not produce flame, they would explode other gases with which they come in contact.

The CHAIRMAN proposed a vote of thanks to the author of the paper.

Professor MERIVALE seconded the motion, and it was agreed to.

The CHAIRMAN said that the first paper for discussion was, "Notes on the Coal-Measures of Catalonia, Spain," by Professor Lebour. He suggested that the discussion be postponed until the paper was issued to the members.

Professor LEBOUR—Yes; allow the discussion to be adjourned.

The CHAIRMAN said the next paper for discussion was, "An Account of Experiments in France upon the possible connection between Movements of the Earth's Crust and the Issues of Gases in Mines," by Mr. M. Walton Brown.

Mr. WALTON BROWN suggested that the discussion be adjourned until the paper was in the hands of the members. (At the close of the meeting he explained the theory and mode of action of a seismograph, which had been ordered by the Committee appointed to investigate the relation which may exist between the issue of gas in mines and micro-seismic motion of the earth's crust.)

The CHAIRMAN said the next paper for discussion was on "Lightning in the Pit at West Thornley," by Mr Henry White.

Mr. WHITE said that the abstract of his paper contained one or two remarks confirmatory of Mr. Massingham's theory, about a place once having been struck with lightning being more liable to be struck again, which the paper itself did not warrant, and he would like it recorded that he (Mr. White) did not believe in Mr. Massingham's theory.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, APRIL 23RD, 1887.

SIR LOWTHIAN BELL, BART., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the previous meeting and reported the proceedings of the Council.

The following gentlemen were elected, having been previously nominated:—

ORDINARY MEMBER—

Mr. WILLIAM GALLOWAY, Mining Engineer, Cardiff.

ASSOCIATE MEMBERS—

Mr. S. AGNIEL, Mines de Vicoigne (Nord) Nœux (P. de C.), France.
Mr. T. F. HEDLEY, Junr., Sunderland.

The following gentlemen were nominated for election:—

ASSOCIATE MEMBERS—

Mr. F. H. EDWARDS, Little Benton, Newcastle-on-Tyne.
Mr. EUSTACE SMITH, Wire Rope Manufacturer and Shipbuilder, Newcastle-on-Tyne.

The SECRETARY read the following paper, by Mr. S. B. Coxon, on "A New Electric Safety-Lamp, with Schanschieff's Primary Single Liquid Battery:"—

MINER'S NEW ELECTRIC SAFETY-LAMP WITH SCHANSCHIEFF'S PRIMARY SINGLE LIQUID BATTERY.

By S. B. COXON.

The writer has prepared this paper with a view of bringing before the members a form of primary battery suited for safety-lamps, so that the relative position of primary and secondary batteries may be fairly considered by the members.

The Schanschieff battery, which has been invented with a view of enabling a sufficient amount of electrical force to be easily obtained in a portable form, has rendered the application of primary batteries to electrical safety-lamps comparatively facile.

There is no denying that the primary battery has seemingly some disadvantages when compared with the secondary one, although these may possibly disappear in practice, and the superior advantage of that perfect independence which is secured by the primary battery become more and more apparent with its use.

It would require no insignificant expenditure of capital to start an installation for renewing the storage of electricity in the secondary batteries attached to some thousand safety-lamps, and a large proportion of this expenditure would have to be incurred even when lamps were being tried, for it is hardly to be supposed that any mining engineer would begin at once to use some 600 or 700 lamps without having previously felt his way by here and there employing a few for some months; and this is where the primary battery would show its advantage, since a colliery manager might order half a dozen and try them for any length of time without procuring any extra plant.

A difficulty has, however, been felt for some time in obtaining a primary battery so simple in its construction as to be easily manipulated by the ordinary colliery staff, and sufficiently portable to do the required amount of work, and as the new single liquid battery invented by Mr. Schanschieff seems to offer many advantages over those hitherto in use, an effort has been made by the inventor to utilise the invention for mining purposes.

The exciting solution is a special preparation of a salt of mercury—

$$(Hg_2SO_4 + Hg\,SO_4 + 3H_2O),$$

3 ozs. of which (per candle per hour, in the case of a miner's lamp) is poured into the cells, so that the carbon and zinc elements which are attached to one end of the lamp are immersed in the solution when that end is held lowest, and withdrawn from the solution when their position is reversed. The receptacle for the liquid and the lamp weigh 1 lb. $12\frac{3}{4}$ ozs., so that a lamp burning eight hours and giving a light equal to one lamp would weigh—

Lamp	=	1 lb.	8 ozs.
Liquid, eight hours × one candle × ·3	=	1 „	$12\frac{3}{4}$ „
		3 „	$4\frac{3}{4}$ „

For comparison it may be noted that—

The Davy lamp full of oil weighs	1 lb.	$9\frac{1}{2}$	ozs.
„ „ in tin case „	2 „	$9\frac{1}{2}$	„
„ Clanny	2 „	12	„
„ Mueseler	2 „	7	„

The batteries are made so that the solution is kept perfectly confined and cannot escape either from one cell to the other, or leak out of the battery, and the lamp complete is so simple that the top can be taken off and the battery emptied and charged by any person, although he may be without any knowledge of electricity. When once charged the lamp can be kept for any length of time with the elements above the solution, and be ready for use in a moment by simply turning the elements into the solution. When one charge is exhausted the used liquid is simply thrown into a glazed earthenware pan, and a fresh quantity of the solution put in the cells.

The advantages claimed for the battery are—

1.—The E.M.F. (1·5 volts) is high and perfectly constant.

2.—The internal resistance is very small, only ·03 ohm.

3.—It gives a perfectly steady current and no polarization is possible.

4.—It gives off no fumes or smell.

5.—It is quiescent when the circuit is open.

6.—It is cheap and durable.

The battery (shown in Plate XIII.) at present to be described is very simple. It is made of lasting materials, and but a moderate amount of cheap exciting liquid is required, and would cost about 17s. 6d. each if made in large numbers.

Figs. 1, 2, and 3 show the lamp in all its details, the same letters referring to the same parts in all the figures.

a is a circular receptacle about 8 inches high and 4½ inches in diameter; this receptacle is divided into three compartments (1, 2, 3, Fig. 3). On one side of the cover is a projection about 2½ inches in diameter, made to receive a small cylindrical box *m* containing the lamp, protected by a strong glass *p* and a few strong wires *o* crossing over it; The top of the cells is circular and mainly composed of three pieces. *d* is a thin piece of india-rubber, *e* a piece of vulcanite about five-eighths of an inch thick, and *f* a wooden top. These are all screwed firmly together by a pin *g*, which runs through the centre of the cells and is secured by nuts at each end.

The carbons and zincs are arranged in the following way:—They are about 3 inches long by 2½ wide and ⅛ thick. *w w* are small brass castings of angular shape, about 2½ inches wide, or the same width as the carbons and zincs, and these are attached to the projecting parts of the angles by means of rivets; the whole of the joints are then covered over with shellac as shown at *y*. These small angles are secured by pins *x*, which run through the india-rubber cover *d* and the vulcanite plate *e*, where there are three recesses drilled in to carry the nuts. The carbons are thus tightly secured to the under side of the india-rubber, and are kept perfectly insulated from each other, the india-rubber rendering the whole liquid-tight.

Fig. 2 shows the mode in which these carbons and zincs are coupled together in all cases, the outside carbons of one cell being connected with the central zinc of the other, and finally to small pieces of metal *u*, *v*, which are fastened to the edge of the vulcanite.

When the top is put on the receptacle, the carbons and zincs project downwards, as shown in Fig. 1, and the two metal plates *u* and *v* press against the little plate *s* bent round the top of the vulcanite receptacle, passing down nearly to the bottom of the tube containing the lamp.

i and i^1 are two handles for holding the lamp, secured, as has been before stated, by two nuts *h h*, one at the top and the other at the bottom of the lamp.

Before putting the top in its place, the exciting solution is to be introduced. This solution is a special preparation of a salt of mercury. When the cells are thus charged the liquid is somewhat less than halfway up them, so that when the top, with the carbons attached, is placed on the cells, the fluid does not touch the plates, which are only immersed in it when the lamp is turned over and held by the bottom handle i^1.

The moment this change of position is effected the lamp is alight, and it is put out as soon as it is replaced in the position shown in Fig. 1.

There are several minor details connected with the lamp; for instance, *j* is a guard which comes over the nut *h* and prevents the top from being taken off the receptacle, and goes down to the hook on the lamp *s*, where it is secured by a padlock *k*, which prevents the lamp being tampered with.

It will be seen that nothing can be easier than pouring fresh liquid into the receptacle, the time occupied in doing so not exceeding that used in supplying the ordinary lamp with oil. When it is necessary to supply a new zinc, all that has to be done is to unscrew the nut *x*, Fig. 1, take the old zinc out, and put a new one in.

This form of battery has many advantages. It gives off no smell or fumes, and when once charged will work the required number of hours for which it is constructed without further attention. The battery can remain charged for any length of time and is always ready for use without special preparation whether the solution has been partially exhausted or not.

It is impossible to give any very detailed estimate of the cost of working the lamp; but as it requires no expensive plant to charge, and has but few parts and these few very inexpensive, it will compare most favourably with the cost of keeping up lamps with secondary batteries.

The PRESIDENT asked Mr. Schanschieff if he had anything to add to the paper?

Mr. SCHANSCHIEFF said, he only wished to explain the difference between the two lamps which he exhibited. The first was the largest both in bulk and weight; it was made for deputies, and gave a light of four or five candles; the smaller one was for hewers, with a light of about two candles. One lamp weighed about four and a half pounds, and the other about six pounds, both being arranged to work eight hours. The exciting liquid, the composition of which he had given in his paper, was new, and perfectly transparent. The cost of keeping the battery at work would be about one penny or three half-pence per shift; the small lamps could be supplied for 17s. 6d. each and the large ones for £1 1s. each.

The PRESIDENT—In fact the liquid is a double salt; but mercury is the base in each case.

To illustrate Mr S. B. Coxon's paper "On an Improved Electric Lamp with Schanschieff's Primary Single Liquid Battery."

FIG. 1.

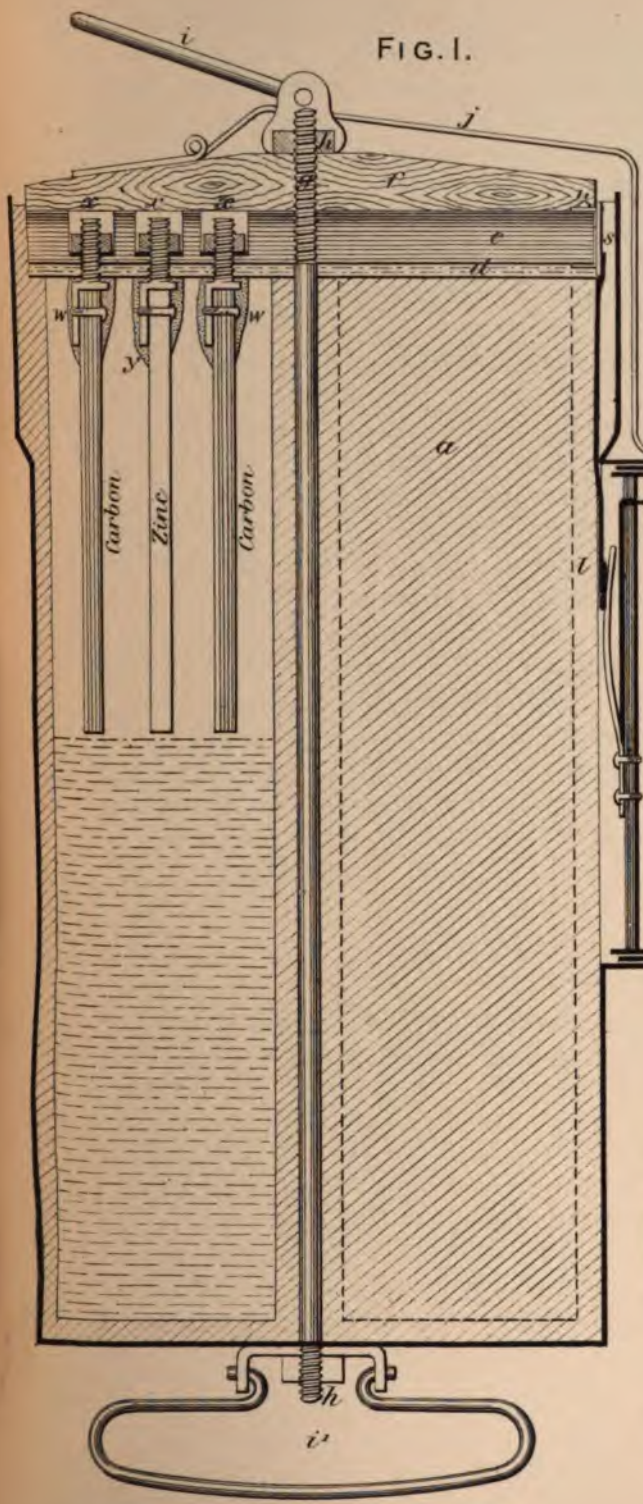
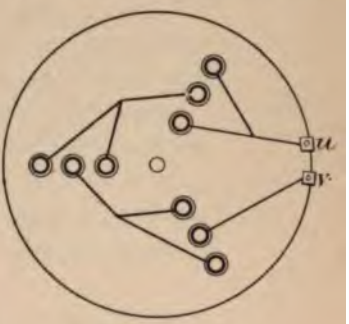


FIG. 2.
SECTION THRO' A.B.



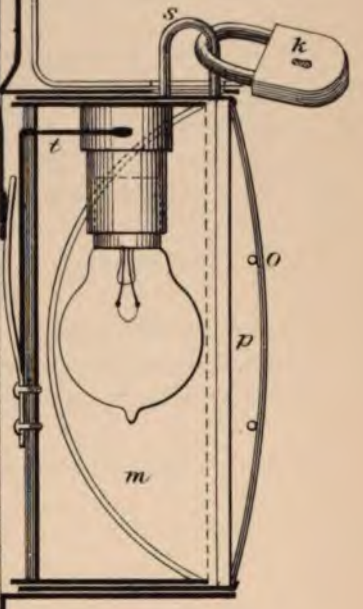
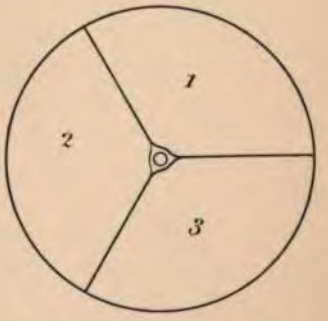


FIG. 3.



SECTION THRO' C.D.

Mr. SCHANSCHIEFF—Yes, in each case.

The PRESIDENT—The large lamp gives a beautiful light.

Mr. SCHANSCHIEFF—It may be as well to remark here that every pains have been taken to enable the lamp to be easily re-charged, and the time requisite to do so has been reduced to something under a minute.

Professor MERIVALE—It would be well to remind the inventor of the importance of having some means of detecting the presence of gas. Mr. Schanschieff's lamp does not indicate either fire-damp or carbonic acid. A lamp to be useful should have some contrivance for detecting both these gases.

The PRESIDENT—That was done by Mr. Swan in his lamp as far as fire-damp was concerned.

Mr. SCHANSCHIEFF said, he had made an arrangement to detect fire-damp, but until he had secured a patent he could not explain it. The battery—the larger one—is expressly designed to have a fire-damp indicator inside of the globe, which can be switched on while the lamp is switched out. By the next meeting he hoped the patent would be secured, and then he would show it attached to a lamp.

Professor MERIVALE asked Mr. Schanschieff if he had made an attempt to make a detector of carbonic acid gas?

Mr. SCHANSCHIEFF replied that he had not. It was very difficult.

The PRESIDENT then moved a vote of thanks to the author of the paper and inventor of the lamp for the trouble they had taken in explaining and exhibiting the lamp.

This was seconded by Mr. MARLEY, and unanimously carried.

Mr. M. WALTON BROWN read the following paper "On a Form of Apparatus for the Rapid Determination of Specific Gravities of Bodies:"—

ON A FORM OF APPARATUS FOR THE RAPID DETERMINATION OF SPECIFIC GRAVITIES OF BODIES.

By M. WALTON BROWN.

The specific gravity of a body is the number which expresses the relation of the weight of a given volume of this body to the weight of the same volume of water.

If M be the weight, V the volume, and D the specific gravity of a body, then—

$$M = V D,$$

and if there is an equal volume of another body, whose weight and specific gravity are M^1 and D^1, then—

$$M^1 = V D^1,$$

$$\text{and} \quad D : D^1 = M : M^1.$$

That is, the specific gravities of the bodies are proportional to the weights of equal volumes of the bodies. If water is assumed as the unit for specific gravity, then the specific gravity of any other substance is the ratio between the weight of any volume of the body and that of an equal volume of water.

The commonly used methods for the determination of the specific gravities of bodies are the hydrostatic balance, the hydrometer, and the specific gravity flask. They are all, however, based upon the principle of ascertaining the weight of the body and that of an equal volume of water, the operations necessary being to weigh the body in air (W) and in water (W^2). The loss of weight ($W - W^2$) is the weight of a volume of water equal to the volume of the body and the specific gravity—

$$D = \frac{W}{W - W^2}.$$

The weighing of a body in water is a tedious operation, and requires considerable technical skill.

It occurred to the writer that this operation might be avoided if an apparatus could be devised which would measure the volume of the body.

The specific gravity would then be determined by the ratio—

$$D = \frac{M}{V}.$$

The following form of apparatus (shown in Fig. 1, Plate XIV.) appears to perform the operation of measuring the volume with sufficient

accuracy. It consists of an accurately graduated burette *a*, and a specific gravity flask of special construction *b*, which are connected together by india-rubber tubing of great thickness and small bore. The flask is fixed on the stand and the burette, when the set screw *c'* is slackened, slides in the supports *e* and *f*, fitted on the stand.

The instrument is partially filled with water before use, the burette is moved upwards until the flask is filled with water nearly to the mark *h* upon the thin tube of the perforated ground-glass stopper, the set screw *c'* is tightened and the more accurate adjustments made by the screw *d*. The height of the water is then read in the graduated burette, Fig. 1.

The body is next carefully weighed, the stopper withdrawn, and the burette lowered so as to partially empty the flask and allow for the overflow of water when the body is placed in the flask. The stopper is then replaced, and the burette raised until the water approaches the mark upon the thin tube of the stopper. The set screw *c'* is tightened, and the level adjusted by the screw *d*. The water will now stand at a higher level in the burette, Fig. 2, as the body will have displaced a volume of water from the flask equal to its own volume. The difference between the two readings of the level of the water in the burette will be the measure of the volume of the body.

The apparatus should be graduated in two forms according as the weight of the body is taken in grammes or grains.

On the metric system the unit of weight is a gramme, which is the weight of a cubic centimetre of water at 4° C., consequently the burette should be graduated in cubic centimetres and decimal divisions.

In Great Britain, according to the Parliamentary Regulations of 1825, a cubic inch of water at a temperature of 62° F. weighs 252·456 grains, and the burette tube is therefore required to be graduated into divisions, each of which represents the 252·456th parts of a cubic inch.

Experiments:—	I.	II.	
The weight of the body is	38·69	52·51	grammes.
The first reading is	30·60	25·30	cubic centimetres.
The second reading is	25·30	13·55	,, ,,
And the volume of the body is ...	5·30	11·75	,, ,,
The specific gravities will therefore be	7·301	4·468	
By the ordinary method the specific gravities were found to be ...	7·330	4·486	
Consequently the error gave less than	·31	and ·40	per cent.

By this apparatus, if a sufficient volume of the mineral be taken, say, about 16 cubic centimetres, or one cubic inch, the error will probably not exceed $\frac{1}{2}$ per cent. If the burette be of small diameter, the most accurate results are readily obtained.

This apparatus can be used for the determination of the specific gravity of all bodies, irrespective of whether they are heavier or lighter than water, and for powdered bodies.

If the body is soluble in water the determination may be made in some fluid, such as naphtha, oil, or mercury, in which it is insoluble, and the product of the number by the specific gravity of the liquid used in the experiment will be the specific gravity of the body.

Mr. M. WALTON BROWN said, that since the above account was written he had seen a description of a form of apparatus (for the same purpose as above described) invented by Mr. F. Pisani, and appearing in *Comptes Rendus*, Vol. 86, 1878, pp. 350–2, which is said to yield approximate results. It consists of a specific gravity flask with a capacity of 5 cm.^{3}, closed by a pierced glass stopper, and provided with a side tube 4 mm. diameter and 25 cm. long. The tube is inclined at an angle of 45° to the flask, is divided into 1-50th of cm.^{3}, and has a capacity of 3 cm^3. Two or three grains of the pounded mineral are weighed. The flask having been filled with water and the stopper inserted, the finger is placed over the hole in the stopper, and the tube placed vertical, when a reading is then taken. A second reading is made with the pounded mineral inside the flask, and the difference of the readings will give its volume. Another form of instrument is described in a recent number of the *Génie Civil*, which appears to be of similar form to the one now described.

The PRESIDENT—There is no doubt, if Mr. Brown is quite accurate, that this is a great simplification of the old way of ascertaining the specific gravity of substances.

Professor LEBOUR said, he had seen the instrument used and knew that it did its work very well. To make an experiment with such an instrument before a large number of people was different from doing it in a quiet room. The apparatus must be exceedingly useful where excessive accuracy was not needed.

The PRESIDENT thought that that was all that was claimed for it.

Professor HERSCHEL said, the measuring of specific gravities by a graduated burette tube had been practised for a considerable time.

This was an improvement by Mr. Brown, who removed the material from the burette tube to a bottle by itself, which was a great convenience. The most that could be done by this displacement method was to find the effective specific gravity of the body, if porous, together with its pores. To fill the pores perfectly with water always required far more careful treatment than could be carried out in an instrument of this kind. In this sense the instrument was a rough one. If they used porous bodies it was not possible without exhaustion and other means to thoroughly fill the pores with water. But if the rapid determination of the specific gravity in bulk was desired, like that of clay iron ore, sandstone, or other matter, for example to know the space required in bulk for a ship's cargo of given weight, it was a very convenient and simple thing for the burette to measure it. It was rather difficult to avoid displacing some of the air from the pores under the old system; a good deal of air was displaced from the pores in the splashing; but if a porous substance was put into a bottle in the way which Mr. Brown had shown them, and water came in from the bottom, it would be better. Mr. Brown's instrument was a great improvement upon what had gone before.

The PRESIDENT said, he had never heard before of the determination of specific gravity being had recourse to in order to ascertain how much a ship will carry of a particular mineral. This is generally ascertained in a far rougher way.

Professor HERSCHEL said, he had once furnished the specific gravity of a quantity of Middlesbro' clay iron ore for the purpose of shipment.

The PRESIDENT—Was it for a shipowner?

Professor HERSCHEL could not mention names.

The PRESIDENT said, he had never heard of it being done himself. No doubt this is a simplification of the previous system, and will be a great convenience, and he proposed a vote of thanks to Mr. Brown for the pains he had taken in trying his invention before them.

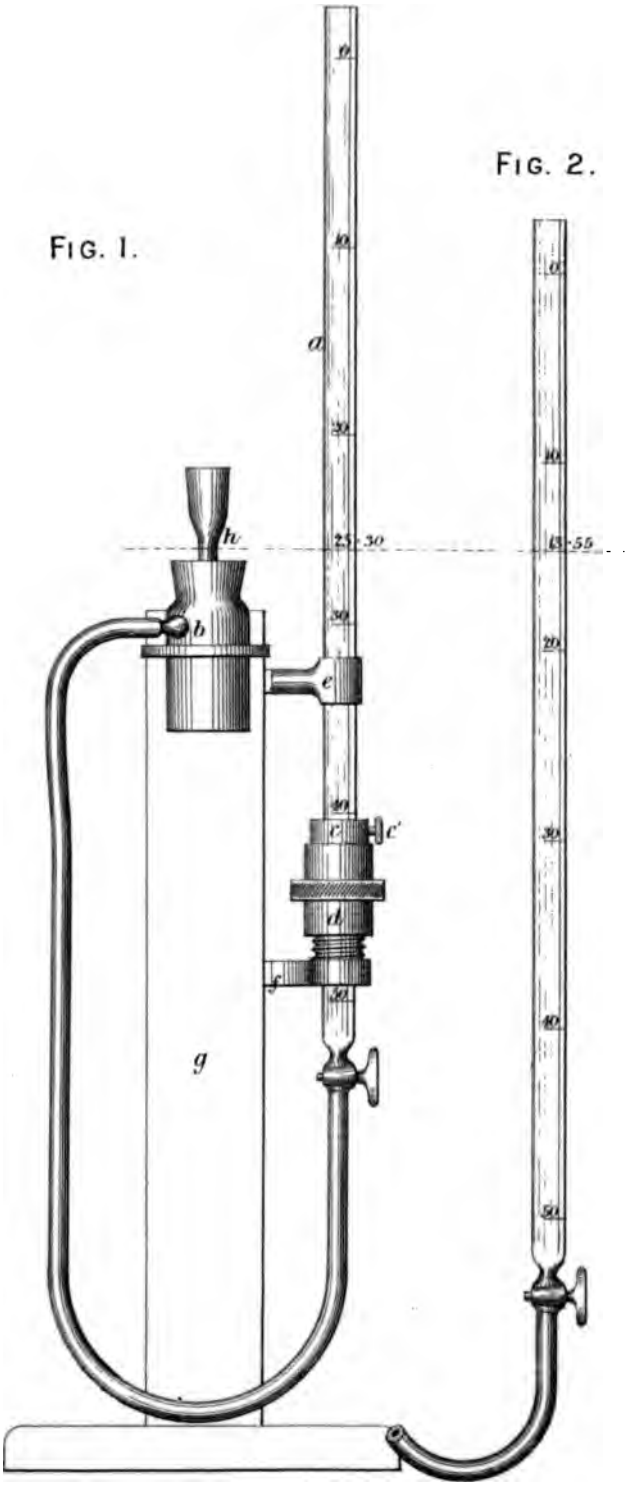
This was seconded by Professor LEBOUR, and unanimously agreed to.

Mr. T. O. ROBSON read the following "Description of Archer and Robson's Patent Sprayer for Laying the Dust in Mines:"—

To illustrate Mr M. Brown's paper "On a form of Apparatus for the rapid determination of the Specific gravities of bodies."

FIG. 1.

FIG. 2.



Andrew Reid, Newcastle.

SHORT DESCRIPTION OF ARCHER AND ROBSON'S PATENT "SPRAYER" FOR LAYING THE DUST IN MINES.

By T. O. ROBSON.

By request of the Council, the writer has pleasure in placing before the members of this Institute a detailed description of a "sprayer," designed for the purpose of damping, and by this means laying, the top, side, and bottom dust in mines.

The question as to whether particles of coal dust contain *per se* the properties necessary to initiate, on contact with flame, and afterwards continue, so rapid a combustion amongst themselves as to cause what is commonly termed an explosion is undecided, and need not be entered upon here. It is sufficient to state that it is now a generally admitted fact that the particles of coal dust lying about the ways of a mine, if they do not initiate, at least serve to perpetuate and intensify, the effects of an explosion where the roadways are dry and the dust exists in sufficient quantity.

In designing an apparatus to render such dust practically harmless as a combustible agent, the following points have been aimed at :—

To effect the emission of a spray, either of water or a mixture of water and common salt, which shall damp and lay the top, side, and bottom dust, and, as far as possible, saturate the air travelling in the roadways—

(1) By means of an apparatus simple in construction and strong in its working parts ;

(2) At a small first cost, and a subsequent nominal working cost.

The "sprayer" (see Plate XV.) is designed so that it can be attached to an ordinary water-tub, traversed by manual, horse, or engine power.

The attachment is effected by means of a hollow spindle *a*, which passes to the outside of the tub through a stuffing-box *b*, and having at its outer end a hollow boss *d*, perforated round its circumference.

Over this inner boss *d* is fitted a chamfered wooden boss *c*, similarly perforated, and surrounded by a circular bristle brush. The wooden boss *c* is made removable, so as to admit of repair and renewal of the brush.

The spindle, boss, and brush rotate upon a carriage *f*, the power to drive them being obtained from the tub axle by bevel or worm wheels *g*, and an endless chain or toothed wheels, driven off the shaft *h* on to the hollow spindle *a*.

A stop-valve arrangement is shown (*k*) for cutting the supply of water from the "sprayer." The form and method of working this valve arrangement can be varied to suit the different circumstances of haulage, roadways, etc.

The water passes along the hollow spindle through the holes on the rim of the boss, and is thrown by centrifugal force from the tips of the bristle brush in the form of fine rain or spray, the speed of emission being in proportion to the rotative speed of the brush.

The tub now in use, with "sprayer," at Redheugh Colliery is constructed to contain 100 gallons of water.

The "sprayer" is geared two and a half times to one of the tub axle, and the diameter of the brush is 15 inches, the hole in the spindle is $\frac{3}{8}$ inch diameter, and the six holes round the rim of the boss are $\frac{1}{4}$ inch each in diameter.

With this quantity of water (100 gallons) it is found that 1,700 yards of way, with a superficial area of 150,000 square feet, can be efficiently sprayed, the tub travelling at a speed of four miles per hour.

Mr. STEAVENSON said, the only question, to his mind, seemed to be whether the quantity of water mentioned by Mr. Robson—100 gallons—was likely to serve for a mile of road? Of course Mr. Robson had had personal experience and could tell how far he had tested the apparatus. Of the danger of dust he thought there need be no two opinions.

Mr. ROBSON said, that at Redheugh one operation of the apparatus would thoroughly damp the dust. The water in the tub had absolutely made an efficient spray for 1,770 yards, making a distinct skin or coating of water over the dust. Of course it would require three or four, or probably more, operations to thoroughly saturate the dust. The results depended entirely on the temperature of the road and the quantity of dust present.

The PRESIDENT—Has there been any opportunity of trying what effect an explosion has upon a surface operated upon by the apparatus? An explosion might blow off the coating of damp coal, and set free the dry dust lying underneath it when dispersed by the explosion.

Mr. ROBSON—There has been no experiment made in that way.

The PRESIDENT—Is the apparatus in use at any colliery?

Mr. ROBSON—Yes, it is occasionally in use on one haulage road at Redheugh Colliery.

The PRESIDENT—And regularly keeps the dust damp in the way mentioned?

Mr. ROBSON—Yes.

Mr. STEAVENSON said, the roads could be gone over several times until thoroughly wet.

Mr. DOUGLAS—How often has it been found necessary to repeat the operation until the dust is saturated?

Mr. ROBSON—The practice has not yet been very extensive. It would require in Redheugh Colliery, where the temperature is not high, to run this sprayer along at least four times per day. The tub is hung on to a set and let go.

Mr. STEAVENSON said that one of the most perfect sprays he had seen was a high-pressure spray of water which impinged upon a very fine pin head. It was the best spray he had seen and was used to cool the House of Commons.

The PRESIDENT—Is it very probable that these very small holes might get stopped with any impurity in the water?

Professor HERSCHEL asked if Mr. Robson found the centrifugal force from the brush sufficient to drive the water with any special strength into small holes? Was he able to raise the water to any height above the tub to reach high places?

Mr. ROBSON said, the holes in the machine were quarter-inch holes. It was not a question of the speed of emission from the holes, but of the water passing from the bristles of the brush. The water was thrown to a height of six feet from the bristles of the brush, the tub travelling at the average speed of four miles.

The PRESIDENT remarked that it seemed a very ingenious way of performing the operation, and that if he were working in a dusty pit he should prefer to have the dust well wetted instead of the air being moistened.

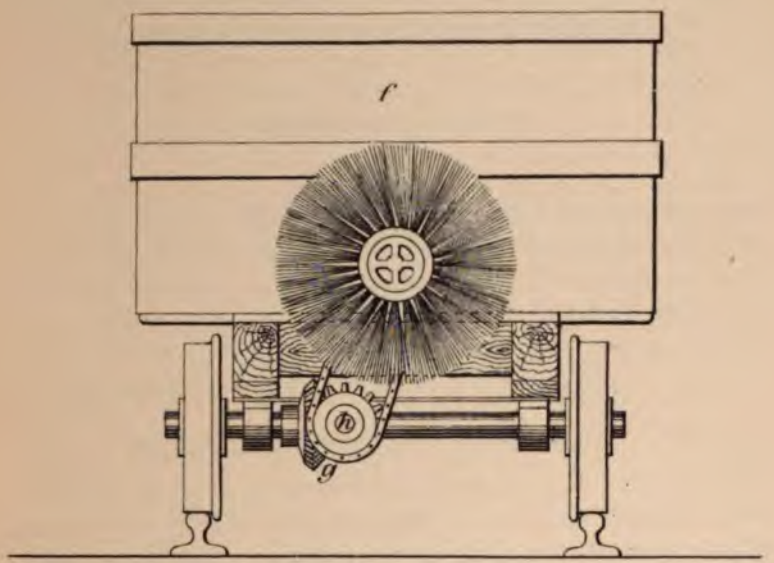
Mr. J. A. RAMSAY said that a few months ago he had designed an apparatus for the same purpose as the one under discussion, but he subsequently heard that the primary part of the machine, which consisted of cranking the axle of one pair of the wheels of the tub, had been introduced for sprinkling water some time before at a colliery in the eastern division of the county. His machine (Mr. Ramsay's) would throw about 2½ pints of water, either in the form of spray or in jets, for each turn of the cranked axle. The apparatus worked submersed, and an ordinary tub,

holding about 100 gallons, would serve about 400 yards of way. For long distances several tubs could be made to serve into the one holding the apparatus. The discharge orifices could be directed so that the water would strike the roof or sides of the galleries. He thought Mr. Robson's machine a very ingenious one, but his design would throw about four times more water per running yard than Mr. Robson's would. He had prepared a paper and diagrams on the subject, but as the apparatus had not been tried they were for the time not accepted by the Council; since then, however, the text and diagrams had been published in one of the weekly technical papers, viz., *The Colliery Guardian*.

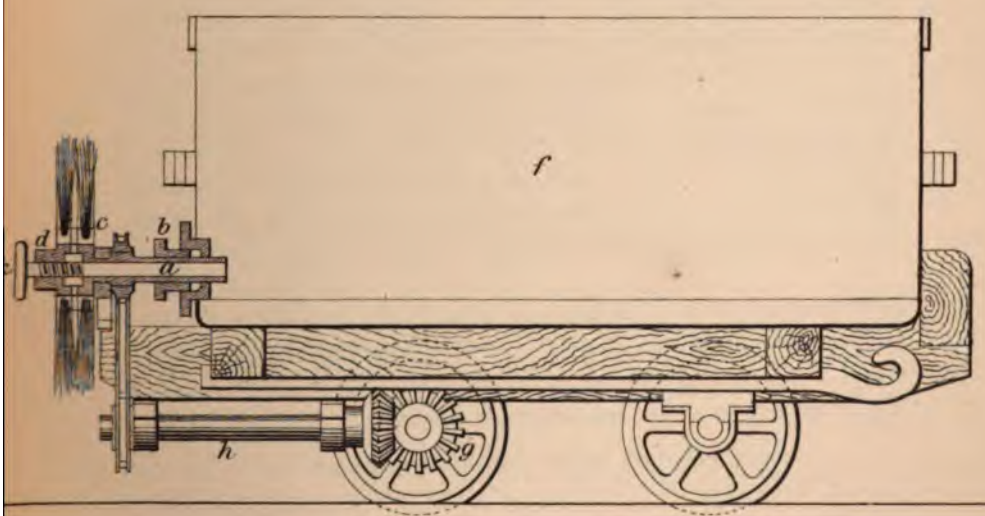
The PRESIDENT proposed a vote of thanks to Mr. Robson, which, seconded by Professor MERIVALE, was unanimously carried.

The following paper, by Mr. E. Halse, on "The Occurrence of Manganese Ore in the Cambrian Rocks of Merionethshire," was read:—

To illustrate Mr T. O. Robson's paper on "An improved method of laying Coal dust in Mines".



END VIEW.



SECTION.

ON THE OCCURRENCE OF MANGANESE ORE IN THE CAMBRIAN ROCKS OF MERIONETHSHIRE.

By EDWARD HALSE, A.R.S.M.

The Cambrian rocks of Merionethshire are comprised in a broad mountain tract, forming an irregular rhomboid or oval, whose longer axis from Barmouth in the south to within about one mile of Ffestiniog in the north covers seventeen miles and trends N. 19 degs. E. (true), and whose shorter axis from Llandanwg, below Harlech, in the west to Rhaiadr Mawddach, near Rhobell Fawr, in the east is ten miles long.

GEOLOGICAL DESCRIPTION OF THE ROCKS.

The area is shown on sheets 59 N.E. and 75 N.E. and S.E. of the Geological Survey. The rocks, according to Sir Andrew Ramsay, "principally consist of coarse quartzite, greenish grey grits, the quartz grains being sometimes associated with interspersed granules of felspar. The rock has often a semi-crystalline aspect. . . . . Occasionally the strata are conglomeratic, quartz, and more rarely felspathic pebbles, being disseminated in a gritty base. . . . . Sometimes they are purple and fine grained, and they are intermingled with occasional bands of greyish green and purple slates, which, especially towards the lower part of the series, attain a considerable development."* Intruded among the lower beds are masses of porphyry, "formed of small granular crystals of quartz set in a compact blue felspathic base. . . . . The rocks in contact with them are altered, and the porphyries . . . present the appearance of rocks that have cooled and consolidated deep beneath the surface."

An immense number of trap ("greenstone") dykes traverse these rocks, running in various directions. Some of them form lodes and lines of fault. While the intrusive porphyries run in a N.S. and N.E. (true) direction, the latter exceptional, the dykes and masses of greenstone run

* *Geology of North Wales*, 2nd ed., 1881, chap. 3.

E.W. and W. of N. as well. In the neighbourhood of Barmouth the prevailing direction is N.N.E., but, speaking generally of the area under consideration, the more usual direction is N.N.W. to N.W., while that of N.E. is exceptional.

NATURE OF THE DEPOSITS.

Three manganese lodes are shown in the one-inch geological map, passing from Barmouth northwards. One starts about three-quarters of a mile north of the town (sheet 59 N.E.), and, running in an unbroken line for about two miles in an almost north and south (true) direction, terminates one quarter of a mile south of the Cennant Egryn brook (sheet 75 S.E.). Two and a half miles further north, and a little to the west, another lode is shown running close to two cromlechs for nearly one mile. About half a mile still further north, and apparently on a line with the Barmouth vein, a third lode courses for nearly one mile along the western side of Y-Foel-wen. These so-called lodes were worked superficially for black oxide of manganese from about 1835 to 1840. The ore was sent to Glasgow for the manufacture of bleaching powder, and fetched from 50s. to 60s. per ton at Barmouth.* The outcrop of the Barmouth deposit can be traced for two miles by means of these old workings. The latter are in no instance more than a few fathoms deep; the black oxide was found not to go down and the veins were at length abandoned. About fifteen months ago it was discovered that the deposits are really the outcrops of one and probably more beds of impure carbonate of manganese, which beds can be traced coming up to the surface at different points right away from Barmouth in the south to within two miles of Ffestiniog in the north; in other words, as far as the Cambrian rocks themselves, and right up to the junction of the Lower Silurian formation. It is only fair to mention, as pointed out by Dr. C. Le Neve Foster,† that although Sir Andrew Ramsay suffered the deposits to be marked down as lodes, they seemed to him "to be merely certain parts of softer and harder strata impregnated with oxide of manganese in the line of strike, that is to say, at right angles to the dip of the Cambrian beds, as shown by the arrows on the map."‡

* For this information the writer is indebted to Mr. J. W. Macqueen, of Macqueen Bros., Manganese Merchants, London.

† *Manganese Mining in Merionethshire.*—A short paper read before Section C (Geology), British Association, Birmingham, 1886. For an abstract see *Geological Magazine*, 1887, p. 38.

‡ Op. cit. c. 8 p. 65.

The fact that one or more exploitable beds of carbonate of manganese are found to occur in the Cambrian rocks of North Wales, and are traceable for a length of seventeen miles, is surely of great interest both from a geological and an economical point of view, and a close study of the bed cannot fail to throw further light on the history of these ancient rocks.

An exploitable bed of carbonate of manganese (rhodochrosite or dialogite) is said to occur in the Upper Salmien (Cambrian) rocks of Chevron, Belgium, but only a brief account of this deposit has as yet appeared.*

POSITION OF THE DEPOSITS.

Plate XVI. is a map of the portion of the area taken from that of the one-inch Geological Survey, and showing the chief outcrops. For the mapping of the latter the writer is indebted to Mr. H. S. Lancaster, manager to the Dyffryn Mining Company, who has been most kind in giving information on, and facilities for studying these interesting deposits. The writer believes some of the outcrops were traced and marked down by Dr. Foster.

Section No. 37 (sheet 75 S.E., etc.) of the Geological Survey (of a portion of which Plate XVII. is a reduction) passes from Harlech through Rhinog Fawr, crosses the Ffestiniog and Dolgelly road, and then goes through the Silurian country to the east. The line must pass through various portions of the beds, although such were not discovered at the time the survey was made. No faults are shown along this section; in fact there is a marked absence of faults throughout the whole area.

The question that naturally suggests itself on looking at these various outcrops is, (1) is there one bed, or (2) are there two or more ?

(1.)—If there be but one bed, it is evident from an examination of the dips that (*a*) the rocks are in places greatly contorted, or (*b*) the bed has been faulted at least once.

The outcrops east and west of Llyn Cwmmynach (Plate XVI.) are clearly on one and the same bed, for they dip in opposite directions, and the Merioneth anticlinal passes between them and close to the lake. The outcrop again at Upper Moelfre dips east, and has, the writer understands, been traced by Dr. Foster, alongside the dingle, up to and beyond Llyn Llawch, and shown to be identical with the outcrop west of Llyn Cwmmynach ; the rocks then clearly form a synclinal between these two

* *Sur la Rhodochrosite de Chevron*, G. Dewalque. *Ann. de la Soc. Géol. de Belgique*, Vol. II. *Proc. Verb.*, pp. 63–65. For an abstract see these *Transactions* for 1884.

outcrops. Again, according to section 37, and the arrows on the map, there is a smaller anticlinal between the Moelfre and Artro mines, and these outcrops, therefore, are no doubt portions of one and the same bed.

(*a.*)—The horizontal sections published by the Geological Survey do not show any great contortions, nothing, for instance, at all resembling those of the Cambrian rocks of Caernarvonshire; and although there is in places evidence of no mean bending, the general average dip of the outcrops is too low—being only about 35 degs.—to account for their present condition through contortion merely.

(*b.*)—There must at least be one large fault. A glance at the map will show that the outcrop of the Moelfre mine is most probably a continuation of that at Cwm-y-afon, two miles further north; and that the Upper Moelfre, Y-Foel-wen, and Cwm Bychan outcrops are portions of one and the same bed. The dip of all these outcrops is to the east; therefore, if they are all parts of one and the same bed, there must be a north and south fault running a little west of Moelfre and Y-Foel-wen for at least four and a half miles, and throwing the strata down to the west about 880 yards. No evidence of such a fault has as yet been discovered. This being so, and until positive evidence of such a fault be forthcoming, it may be as well to refer to

(2.)—Mr. Lancaster, the manager of the chief mines, who has from the first been of the opinion that there are at least two beds of ore, mainly because (*a*) of the difference in the proportions of the constituents in different places, and (*b*) of the varying thickness of the overlying blue banded rock and chloritic schist. These reasons alone are not sufficient to dispose of the view that there may be but one bed, for over such a large area such variations may be expected to occur. A stronger and additional reason is the marked absence of faults in the area under consideration. Plate XVIII., Fig. 1, is a horizontal section showing the portions of the outcrops west of Upper Moelfre—the dips corresponding to those shown on the Geological Survey section (Plate XVII.)—which either have actually been proved to cross the section, or which must do so at or near the points marked down. The dotted lines west of Artro are intended to indicate the probable contortion of the beds of that portion of the area. If this view be correct, there are two beds from five to six hundred yards apart, the upper one of which corresponds to the Llyn Cwmmynach Diphwys, Hafodty, Upper Moelfre, Y-Foel-wen, Cwm Bychan, Llyn Ciddew Mawr, and Harlech outcrops; and the lower to the Moelfre, Cwm-y-afon, Artro, and minor outcrops between Harlech and Artro. As a matter of fact, Mr. Lancaster informs the writer that the "Upper

Moelfre and Harlech deposits have many characteristics in common," and he looks upon the above explanation as a very likely solution of the matter.

DESCRIPTION OF THE DEPOSITS.

Several of the more important outcrops were examined by the writer last autumn, and will be described going from Harlech eastwards.

Harlech Mine.—About one mile from Harlech, along the turnpike road going northward, the bed is seen to crop out on the east side of the road. Several galleries were driven into the seam, and it was actively exploited for about twelve months. The bed at the mouth of one gallery was found to dip from 25 degs. to 30 degs. E. Elsewhere, a vein of spar four feet wide, and striking N. 30 degs. W.,* cuts through the bed and strata, and a fault running N. 15 degs. E. throws the bed down twelve feet to the west. Plate XVIII., Fig. 2, is the vertical section seen at the above gallery. The bed of ore is a little over one foot thick. Immediately below it is a thin band of quartzite, probably metamorphosed grit; below that is the floor proper, consisting of grit of medium grain. Above the bed is chloritic schist, scattered throughout with magnetite and crystals of pyrites. This schist, especially near the surface, is decomposed to a shale. Above the band of chloritic schist is the roof proper, consisting of about two feet of a very hard schistose rock, termed "bluestone" by the miners. It is usually of a slate-blue colour, and streaked with white layers besprinkled with iron pyrites. These white layers effervesce in hydrochloric acid, and give a strong manganese reaction before the blowpipe. The whole band of rock is scattered throughout with flakes of mica and magnetite, and probably contains as well both quartz and felspar. The magnetite is sometimes plainly visible to the naked eye, but usually it can only be properly seen with a lens. Certain layers are so plentifully besprinkled with this mineral as to have a reddish appearance. These remarks apply generally to the bluestone wherever it occurs, but, of course, the above characters vary at different points. It is always found above the ore-bed, except, of course, in cases of reversal, but the thickness varies a good deal. The bluestone has been found to contain from eight to ten per cent. of metallic manganese. The manganese is probably present as carbonate in the white streaks.

At Harlech the ore immediately below the chloritic schist is greenish, brittle, and of shaly appearance; below that the ore is hard and of a prevailing chocolate brown colour. Specimens of ore taken from the mine are seen to be formed of uniform layers, having grey, yellowish white, greenish, and chocolate brown colours.

* The readings are magnetic, 1886, unless otherwise stated.

The mine is one mile from the Harlech Station on the Cambrian coast-line. The cost of carriage is ninepence per ton. Here 15 cubic feet of ore equal 1 ton. The greatest profit obtained from these workings was about sixpence per ton. The bed being faulted, and the ore of low grade (averaging only 27 per cent. metal), and the rock proving very hard, the mine is now (March, 1887) being stopped.

The bed, being of moderate dip and thickness, is worked in the ordinary manner of bedded deposits. On account of the hardness of the roof the workings are kept low. A prop is put in here and there to keep the roof up, and the workings are packed with the rock from the roof wherever possible. These remarks apply to the other exploitations, with the exception of that at Hafodty.

The beds of rock by the side of the highroad south of the mine dip east from 14 degs. to 16 degs. The main vertical joints run from N.N.E. to N.N.W., and dip from 84 degs. W. to 85 degs. E. Minor joints run N. 35 degs. E., dipping E., and here and there cutting the rock up into rhombohedral-shaped pieces. The ore-bed, especially near the surface, often breaks up into similarly shaped fragments (see Plate XIX., Fig. 4), and the minor joints are sometimes filled with an inch or so of massive quartz. Near the surface the ore is oxidised to a great extent.

Artro Mine.—The dip here is only 13 degs. E. A glance at Plate XVIII. will show that this deposit forms a shallow basin, and that further west it must crop up with an opposite dip. The bed is not faulted like the Harlech deposit, but it frequently takes a roll downwards and upwards for a foot or so in vertical extent. Plate XVIII., Fig. 3, shows the average section at this mine according to Mr. Lancaster. The bluestone is here very thick and the chloritic schist is absent. The ore is irregular in quality in different points. The thickness varies from 8 to 18 inches. The floor is grit. Near the surface the ore is decomposed to dark brown hydrated oxide of manganese having a dull metallic lustre, or to yellow ochre, with a coating of the same mineral. The ore, where undecomposed, consists of uniform layers having grey, yellowish white, green, and greenish brown colours, the predominating tint being grey. Some specimens of ore are well besprinkled with rather large cubical crystals of iron pyrites, and also show quartz running across the layers.

The cost of cartage is 2s. 9d. per ton, and the ore is worth about 16s. per ton at the Llanbedr Station.

Moelfre Mine.—The bed here is remarkable for its contortions. Sharp folds occur every two or three yards, and often at every two or three feet. Figs. 3 and 5, Plate XIX., show contortions seen by the writer close to

the mouth of two of the galleries. In one, blackish manganiferous shale appears to replace chloritic schist, and there is a thin band of the latter below. Hand specimens can be picked up exhibiting very abrupt bendings. Figs. 1 and 2 are diagrams of two of which sections have been cut. The originals must be seen in order to appreciate their great delicacy of lines and tints. Very much contorted specimens show alternate layers having grey, greenish, yellowish grey, and chocolate brown colours (latter predominating—Fig. 1). One large specimen was coloured yellowish grey and chocolate brown. In another (Fig. 2) the colours were greenish yellow, dark grey, greenish grey (predominating), and chocolate brown (rare). In another, light grey (predominating) and yellowish grey. Iron pyrites in small cubes are scattered through the ore. Fig. 4, Plate XVIII., is a vertical section seen at one point. The little band of grit in the ore itself is stained black above. The ore is a good deal oxidised and irregular, and does not break into rhombohedral pieces so readily as elsewhere. Quartz is common, running across the ore layers. The ore contains 4½ per cent. of iron.

Barmouth.—The outcrop of the upper or Hafodty bed can be traced in a southerly direction right away to the sea at Barmouth. A little working has been done on the bed in the cliff at the back of the town. Here the bed dips from 26 degs. to 30 degs. S.S.E., and is from 9 to 15 inches thick, with a floor of greasy greenish beds (chloritic schist), and a roof of greenish coloured rock (? bluestone). The bed is in places rolled like the Harlech deposit, and is a good deal oxidised.

Hafodty Mine.—Above Barmouth the beds are contorted, but not so much so as at Moelfre. The thickness varies a good deal. In one place it was 19 inches, while in another, where greatly folded, 12 inches. The dip also varies considerably; the average is high, being about 60 degs. E. (which will account for the outcrop being taken for the back of a lode); in some places it is 75 degs., while in others it is as low as 30 degs., horizontal, or even turned right over. The ore is usually of a light brown colour, and of very uniform quality. The percentage of manganese varies from 30 to 32, and that of silica from 18 to 19. As might be expected where the manganese is high the silica is low, and *vice versa*. The richest ore is where the bed is thinnest, or in other words, where most bent or compressed. Fig. 5, Plate XVIII., shows the average section of this deposit according to Mr. Lancaster. The band of chloritic schist varies from 1 to 6 inches, and that of the ore from 18 to 20 inches. There is sometimes a thin layer of chloritic schist between the ore-bed and the grit floor. The roof very much resembles the Artro roof. The best ore

consists of yellowish white, light yellowish brown, and rosy or slightly purple coloured layers, light yellowish brown predominating; where contorted, of dark grey, greenish, and light yellowish brown coloured layers, dark grey predominating.

The ore is oxidised, especially near the surface, to dull brownish black, and comparatively soft pieces, with unchanged ore (see Plate XIX., Fig. 4), or generally yellow ochre in the centre. The outer coating, often glistening, quite black, and comparatively hard, forms a strong contrast to the latter. Near the ochre the outer black coating is yellowish and softer. Much of the ore near the surface breaks up into rhombohedral pieces. One specimen, measuring 2 by 1½ inches, with an outer black coating three-tenths of an inch thick, shows quartz veins parallel with the longer sides. The angle at two opposite edges is 70 degs., but it varies a good deal. Another specimen, measuring two by sixteen-tenth inches, has an hydrated coating from three-tenths to between three and four-tenths of an inch thick. Given moisture and exposure to the air the ore speedily oxidises; that in the heaps left by former workers is now oxidised throughout.

The dip being high, this outcrop is worked in the manner of a lode—the ground is regularly stoped away. It is kept up with posts and slabs, and, here and there, where the bed is thin, the ground is left whole. Several galleries have been driven into and along the bed, which, measured vertically, are very near together. Presumably, the bed is worked in this way in order to win the mineral as rapidly as possible. As the ground rises northward, and the outcrops extend for a long distance in that direction, it was found necessary to lay down several short self-acting planes (jig-brows) to bring the ore down to a lower level. It is proposed to put down a wire tramway from the mine across the hilly and exceedingly rough ground to Barmouth. Mr. Lancaster, the manager, has planned a scheme for this purpose, which is calculated to cost only £130 per mile.

Here 10 cubic feet of ore equal 1 ton in weight. The ore, when calcined, yields 34 per cent. of metal. One fault (a downthrow) has been found having a horizontal (W.) displacement of about 20 yards, and a vertical one of 7 yards. The cartage is about 3s. per ton. The ore is worth about 30s. per ton f.o.b. at Barmouth.

Cwm Bychan.—The writer did not examine the Upper Moelfre, Y-Foel-wen, and Cwm Bychan outcrops. He looked for the latter, but owing to a heavy mist, was unable to find it, but Mr. Lancaster told him the bed there is five feet thick, but contained only 19 per cent. of metal, and as it is 6½ miles from the nearest station, it will not pay to work.

Llyn Ciddew Mawr.—This outcrop is about two miles further north. A line joining it with the Y-Foel-wen and Cwm Bychan outcrops passes about N. 9 degs. E. (true), and this may be taken as the average strike of the bed. The ore-bed, at the point chosen for examination, appeared to course about N.E. and to dip N.W. 27 degs. It is from 12 to 15 inches thick, and is intersected by cleavage planes which run N. and S. The chief joints run N.N.E. and dip 78 degs. S.E.

The ore, in colour and appearance, is similar to the Artro ore. There are two inches of greenish grey ore at the top of the bed. The main portion consists of from 6 to 7 inches of ore of a chocolate brown colour. Immediately below the bed there is chloritic schist, plentifully besprinkled with large crystals of iron pyrites. Directly above there are two inches of very hard rock (? grit), and above that the rock is moderately hard, becoming shaly, greener in colour, and less hard near the surface. The dip of the beds at the lake is 27½ degs. S.W., and south of the lake 27 degs. N.W.

Hendrecerrig.—Still further north on the Hendrecerrig farm, and close to where the Cambrian dip under the Silurian rocks, there appeared to be a slight exposure of the same bed which dipped 36 degs. W., and ran N.W., but the section was somewhat confused and the thickness uncertain. At the writer's suggestion, this was further opened into, and he believes that the bed has since been exposed, and proved to be from 2 to 3 feet thick. This outcrop occurs in the rocks on the north side of the dingle, and close to the banks of the stream which for a long way forms the southern boundary of the Hendrecerrig and Aberdeunant farms. In the rocks above this point there are brownish white layers of what appears to be carbonate of manganese,* alternating with bands of a schistose rock (? bluestone), dipping W. 30 degs. The layers of ore are from 1½ to 2 inches and less thick, while the bands of rock between are from 2 to 2½ inches thick, and they appear to be traceable through a thickness of rock ranging from 2½ to 5, and probably more, feet thick. Cleavage planes are visible, dipping at a high angle in the bands of rock, while in the bands of ore these planes are vertical, indicating that the latter were bent or refracted when passing through the harder layers. The ore is scattered throughout with small crystals of iron pyrites and magnetite. The main joints of the rocks here dip 76 degs. E., and run nearly N.S.

Diphwys.—Mr. Lancaster states that the ore bed is here 15 inches thick. The roof, consisting of the usual bluestone, is 3½ feet thick,

* The layers effervesce in hydrochloric acid, and give a manganese reaction before the blowpipe.

Locality.	Average Width.	Roof.	Floor.	Strike.	Dip.	Percentage of Metal	Percentage of Silica.	Character of Ore.	Strike of Chief Rock Joints.	Remarks.
	Inches.									
Harlech Mine ...	12	Chloritic schist and bluestone	Quartzite, shale, and grit	...	E. 25°–30°	27	25–27	Chocolate brown colour—hard	N.N.E.	Bed faulted.
Artro Mine	13	Bluestone	Grit	...	E. 13°	27	25–27	Grey colour-hard	...	Bed subject to rolls, layers show slight curvature.
Moelfre Mine ...	9	Shale, chloritic schist, and bluestone (?)	Chloritic schist, schistose rock, and grit (?)	N. 10° E.	E. 63° (?)*	26	21	Light grey colour	...	Bed much contorted, cleavage planes visible.
Barmouth.....	15	Bluestone	Chloritic schist and grit	...	E. 30°	...	...	.....	...	Bed subject to rolls.
Hafodty Mine...	19	Chloritic schist and bluestone	Grit	...	E. 60°	31	18½	Light yellowish brown colour	...	Bed contorted and faulted.
Llyn-eiddew ...	13½	Chloritic shale and bluestone†	Chloritic schist and grit‡	N.E.	S.W. 27½°	...	...	Chocolate brown colour	N.N.E.	Cleavage visible.
Hendrecerrig ...	30	.....	.....	N.W.	W. 30°	...	...	Light greenish colour	N.S.	Layers regular.
Diphwys	15	Bluestone	Chloritic schist and grit	...	W. 30°	32–33	18	.....	...	Layers regular.
Burleux (Chevron)	24	.....	.....	...	...	21¼	22½	Rose-coloured rhodochrosite and ribboned quartz	...	Two assays gave 75-84 per cent. of carbonate of manganese, the rest was a little carbonate of iron and magnesia.§

* The average dip appears to be low—a little further north the dip of the rocks was W. 3°.

† Immediately above the bed this rock alternates with thin layers of oxidised ore.

‡ A thin band of grit occurs between the bed and the chloritic schist.

§ G. Dewalque, *Sur la Rhodochrosite de Chevron*, *Ann. Soc. Geol. Belgique* t. xi., Bulletin, p. lxiii.

and between the bed and the grit floor there are 6 inches of chloritic schist, containing mundic, etc., but this rock is occasionally absent. The ore assays 31 and 32 per cent. of metal, hence it is richer than at Hafodty. The bed is regular in stratification, and dips W. 30 degs. It has been found running north from Diphwys Mountain, passing Cefn Clwydd, three miles west of Trawsfynydd, as far as Maentwrog (sheet 75 N.E.). The ore at Llyn Cwmmynach is said to be purplish in colour.

In the table on the opposite page the different outcrops are compared with each other, and with the analogous Belgian deposit.

Speaking generally, the richness of the ore declines westwards and northwards. Between Diphwys and Harlech the loss is six, and between Hafodty and Cwm Bychan twelve units.

Not taking into account the outcrop at Cwm Bychan, where the thickness is exceptional, and that at Hendrecerrig, where it has not been verified, the average width of the upper bed seems to be about 15 inches while that of the lower is 12 inches, and the average percentage of manganese of the former is 30 while that of the latter is 26½. The colour of the ore varies a good deal from point to point, but, speaking very generally, while the prevailing colour of the upper bed is brown, that of the lower appears to be grey. In both beds bluestone invariably occurs above and grit below the seam. The variation in the thickness of the roof and floor proper, and the occasional appearance and disappearance of bands of chloritic schist, have already been pointed out; but it is noticeable that at Moelfre, where the contortion has been greatest, the chloritic schist is thickest and the bluestone thinnest, while at Artro, where the stratification is fairly regular, no chloritic schist is present, and the bluestone is at its greatest width. It would seem, as one might have expected, that the greatest amount of metamorphism coincides with the greatest amount of contortion.

COMPOSITION OF THE ORE.

Thanks to the courtesy of Mr. Lancaster, the writer is able to give a complete analysis of one of the lower class ores, made, he believes, by Mr. Holgate, analyst to the Dyffryn Mining Company. In the table on page 114, this analysis is compared with that of two specimens of the Belgian ore.

The Merionethshire ore effervesces pretty briskly in dilute hydrochloric acid, and gives a strong manganese reaction before the blowpipe. It is low in phosphorus and iron, high in silica and alumina, and only moderately rich in manganese, while the Belgian mineral is high in

phosphorus, silica, and iron, low in alumina, and less rich in manganese than the Welsh ore. The specific gravity of the latter (from Hafodty) is 3·61.

Constituents.	Merioneth-shire Ore (Analyst, Mr Holgate) Dried at 212° F.	Merioneth-shire Ore (Analyst, Mr Holgate) as Received.	Chevron Ore (Analyst, M. F. Lacone) from Heid Julien.	Chevron Ore (Analyst, M. F. Lacone) from Heid Cossin.
Moisture	...	2·499	...	...
Manganese Peroxide	8·07	7·87	} 28·42	{ 31·75
„ Protoxide	26·72	26·05		
Iron Peroxide	5·71	5·57	29·62	24·15
Alumina	10·99	10·72	3·87	4·06
Lime	4·31	4·20	3·90	2·83
Magnesia	0·62	0·60	1·15	0·88
Silica	26·67	26·00	23·22	22·01
Potash and Soda	0·25	0·24	...	...
Phosphoric Acid	0·074	0·072	0·55	0·46
Sulphuric Acid	0·17	0·16	Trace	0·01
Copper and Lead	Nil.	Nil.	CO_2 { ...	CO_2 { ...
Loss on ignition inclusive of 12·83 Carbonic Acid	15·70	15·31	{ 10·63	{ 14·51
	99·284	99·291	101·36	100·66
Manganese	25·8	25·05	20·48	22·87
Iron	4·0	3·90	20·73	16·90
Phosphorus	0·043	0·042	0·24	0·20

If the whole of the carbonic acid present in the Welsh ore is taken up by protoxide of manganese, it contains 33½ per cent. of the carbonate; but doubtless there are present several units per cent. of iron, magnesium, and calcium carbonates. Mr. Holgate finds there is 4 per cent. of silicate of manganese in the ore, the remaining protoxide and peroxide are probably combined together.

The ore is clearly a mechanical mixture, and seems to be made up of about—

30 per cent. carbonate of manganese.
4 „ silicate of manganese.
40 „ oxides of manganese, iron as oxide (magnetite), carbonate, and sulphide (iron pyrites), magnesium carbonate, etc., and free silica.
26 „ clay.

100

If the whole of the carbonic acid in the Belgian ore is combined with protoxide of manganese, it contains 32½ per cent. of the carbonate. Hence the curious fact appears, that both these deposits contain about the same quantity of the latter mineral.

WORKING COST AND OUTPUT.

The ground is set by the yard, the average price being 35s., but of course it varies much. The writer is unable to give any figures with regard to the cost of getting. As the beds of ore are of only moderate thickness and quality, and as the ground has proved to be of very stubborn nature, the margin for profit can only be a moderate one.

Last autumn the Dyffryn Mining Company's output was as follows:—

The Harlech mine yielded about	...	100 tons per week.	
The Artro mine	,,	... 130	,, ,,
The Moelfre mine	,,	... 70	,, ,,
The Hafodty mine	,,	... 100	,, ,,

or a total of 400 tons per week. Although the Harlech mine is being stopped this output will not be diminished, as the Diphwys deposit, which has only very recently been opened out, supplies the smelting works with 100 tons weekly. The manager believes he can double the above output. The writer has no figures relating to the output of the Merionethshire Manganese Company, who are working the chief remaining setts, but it probably does not exceed 100 tons per week.

TREATMENT.

The ore is calcined, and then smelted in a blast furnace with iron and a richer class of manganese ores, so as to produce an alloy between spiegeleisen and ferromanganese, and which, containing 45 per cent. of manganese, is known in the market as "forty-five." It is mainly exported to America, and used in steel industries.

ORIGIN OF THE BEDS.

Whether the beds were formed on the bottom of the old Cambrian sea,* on that of a large lake, or below peat bogs† of great extent—and the former supposition seems to be the more probable—the writer is inclined to regard them as having had, directly or indirectly, an organic origin, notwithstanding that the evidences of the existence of life during the

* Compare *Manganese in the Sea*, A. H. Church in *Mineralogical Magazine*, Vol. I., pp. 50-53.

† At Glendre, in the County of Clare, Ireland, diallogite (carbonate of manganese) forms a layer, two inches thick, below a bog, and has a yellowish grey colour.—See Dana, *System of Mineralogy*.

deposition of this portion of the Cambrian formation are but slight.* The ore was deposited entirely as carbonate, or partly as carbonate and partly as hydrated oxide, together with clay, sand, and other impurities. The presence of silicate of manganese and of free oxides in the ore shows that the beds have undergone a certain amount of change since they were formed on the sea bottom.

There is evidence that the beds, after having been formed, consolidated and elevated far above sea-level, were subjected to great pressure, acting mainly in an east and west direction. The result has been contortion—more plainly visible in some places than in others—and a certain amount of metamorphism.

As the general trend of the cleavage in this area is identical with that of the Cambrian rocks of Caernarvonshire, the same causes may have produced both; but in the latter county, the pressure was sharper or more prolonged, producing greater contortion, and more perfect slates.

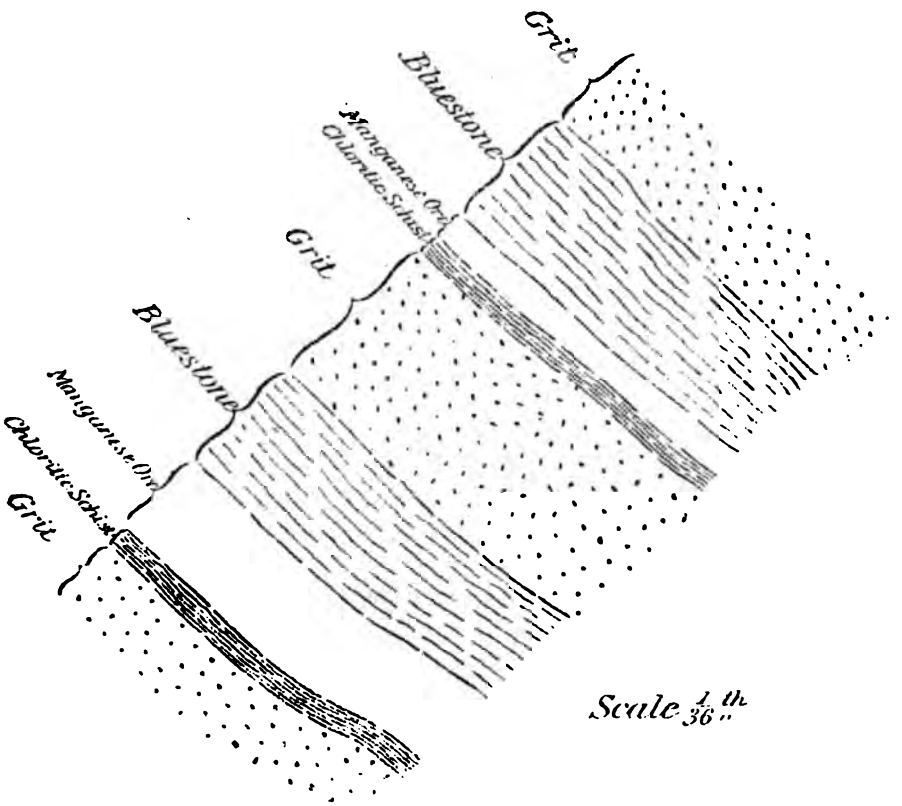
Since writing the above, Mr. Lancaster has sent the section given on the next page, occurring where the upper bed has been bared on the side of a valley, about one mile from the Hafodty mine. Here a distinct band of ore occurs above the ordinary bed, and separated from it by five feet of grit and bluestone. The upper thin layer is highly siliceous, but the lower one is of good quality. There are no rolls at this place, and the stratification in the immediate vicinity is comparatively regular. Mr. Lancaster has seen the same thing at Moelfre, but there the interbedded rock is grit, and only from 3 to 4 inches thick. The occurrence of thin layers of manganese ore in the schistose rock of Hendrecerrig, and in the bluestone has already been noticed. The writer thinks it highly probable that a careful examination will show that a good thickness of the Cambrian rocks is manganiferous in this sense. It is not unlikely that the purple colouring of certain of the slates and grits of this area is due to the presence in them of manganese.

The PRESIDENT—Are the mines being worked?

Professor LEBOUR—Yes, five or six mines have been for several years.

The PRESIDENT—It is to be hoped that all geologists are fully aware

* "Except annelide tracks and borings, no fossils have yet been observed in the Cambrian strata of Merionethshire."—Sir Andrew Ramsay, op. cit., p. 20.



of the great inconvenience it would be to the world if its manganese supplies failed, for then there would be no bleaching powder, and very little Bessemer steel.

Professor LEBOUR—Manganese has been found, not very long ago, at Riding Mill, but the occurrence has not been examined very carefully.

The PRESIDENT moved a vote of thanks to Mr. Halse for his paper, which was seconded by Professor LEBOUR, and unanimously passed.

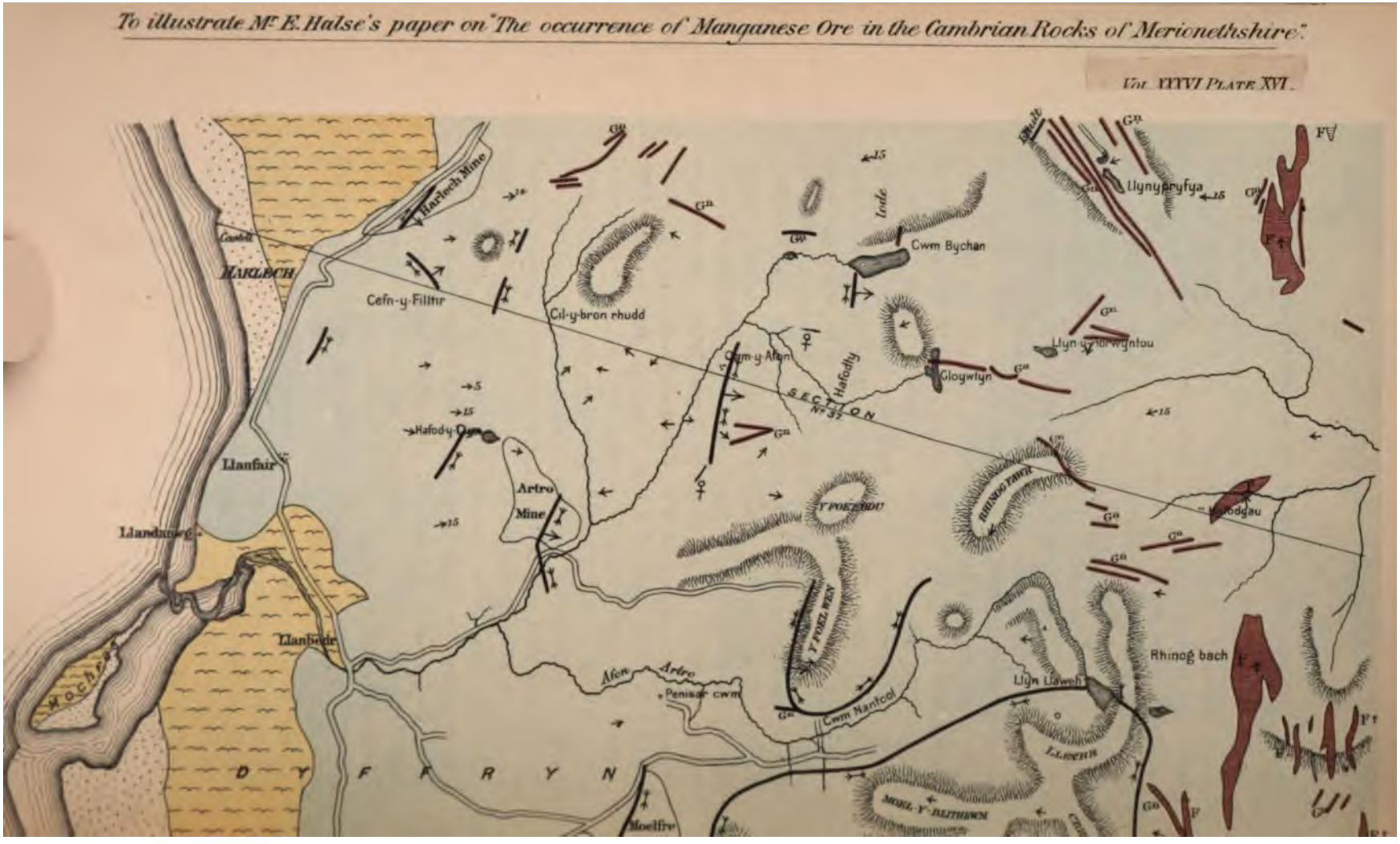
The following paper was announced to be open for discussion:—"Notes on the Coal-Measures of Catalonia, Spain," by Professor Lebour.

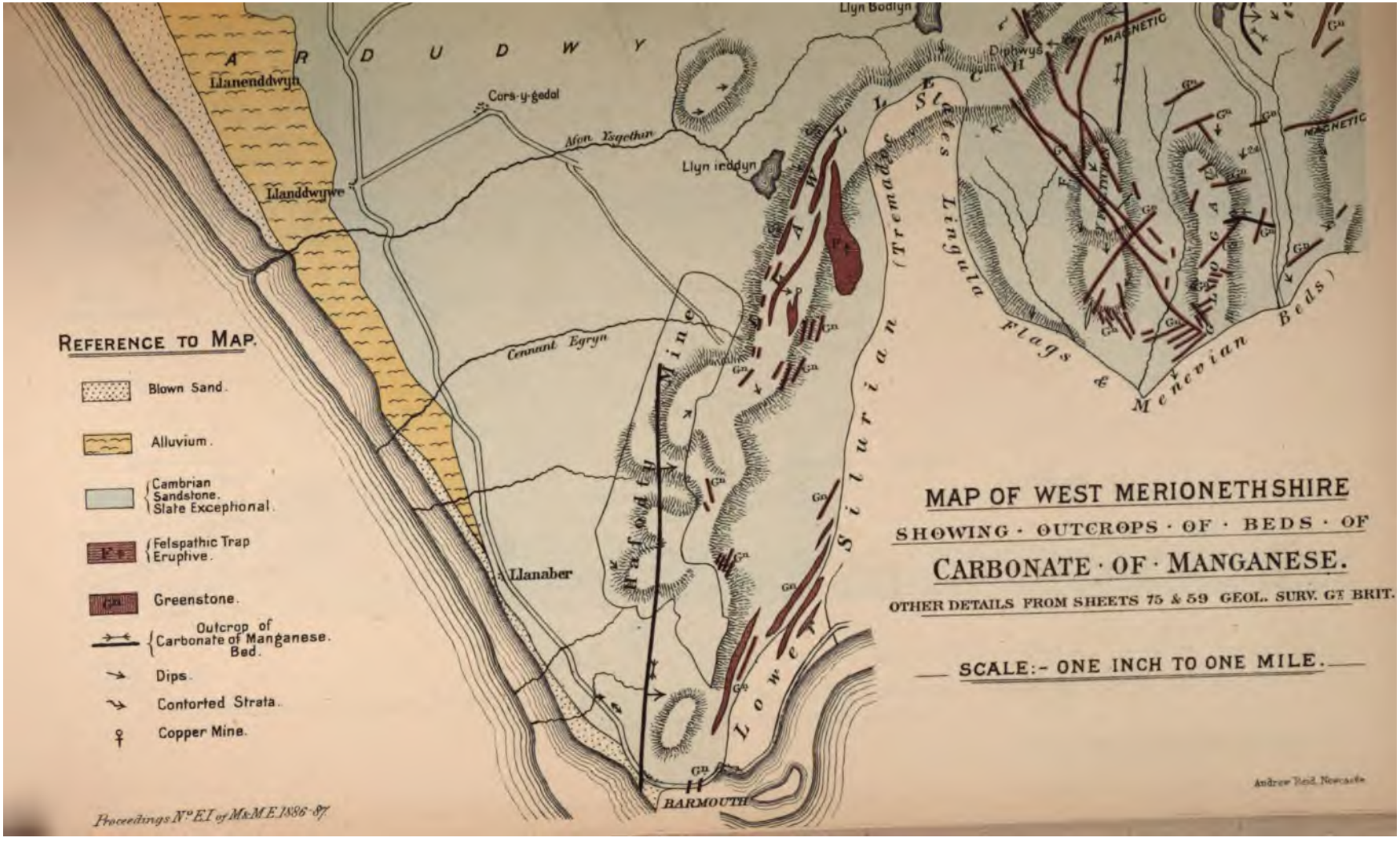
Mr. JOHN MARLEY said, he understood that the object of Professor Lebour in reading the paper was, to a certain extent, to identify the geological position or the continuation of the Catalonia coal-field with that of the Asturias, and he (Mr. Marley) thought probably his own experience in the north part of Spain, as well as that of his son, Mr. J.

W. Marley, who had been there upwards of a year, in connection with the San Cebrian Coal Mines and Railway in the Province of Palencia, might perhaps help to clear up this point. He was sorry Professor Lebour had not given the Institute a better geological plan in connection with Spain than he had done. The Catalonia coal-field was some fifty miles north of Barcelona. Professor Lebour seemed to have omitted the coal-fields which are in the Province of Palencia. In that province, for upwards of twelve years, the Barruela coal-field had been connected by a branch railway with the Northern Railway of Spain running from Santander to Madrid, and subsequent to this connection the Northern Railway of Spain was supplied with the bulk of their briquettes from this mine. The Barruela colliery, which he visited, supplied 350 tons of coal per day; he was going to say "working day," but the working day was during the whole of the week, including Sunday, the only holidays being the saints' days. He would say 150,000 tons per year. This would show that it was a very important coal-field. This coal-field geologically agreed with the Catalonia coal-field. The Coal-Measures generally were lying at an angle of from 40 to 50, and even up to 90 degrees, and were generally, or at least frequently, covered with trias, not conformable. So far as his son and himself had been able to identify them they were of the true Coal-Measures. In addition to the Barruela, there was another colliery at Orbo, near thereto, which used to be under a separate ownership, but which had now been purchased by the Northern Railway of Spain. Immediately below the Coal-Measures were the mountain limestones, lying conformably, and considerably further below was the Devonian. The Catalonia, Burgos, and Leon coal-fields mentioned by Professor Lebour, were all on the south side of the Cantabrian Mountains. There was no doubt in his (Mr. Marley's) mind whatever that they were practically and geologically a continuous coal field on the south side of the Cantabrians, and could be identified geologically with the Asturias field on the north side of the Cantabrians. This seemed to be the point which Professor Lebour desired to have somewhat strengthened. He enumerated the coal-fields, which were divided by the Cantabrian mountains as follows:—San Cebrian, Barruela, Orbo. It might be considered this was a continuous line from Catalonia to the Asturias, and was, he had no doubt, geologically the same both on the north and south of the Cantabrians. Professor Lebour had given some information as to the fitting up of some of the Catalonian collieries. Since the Barruela mines had been connected with the main railway, the owners had gone to considerable expense in fitting up the shaft. Although the coal was principally

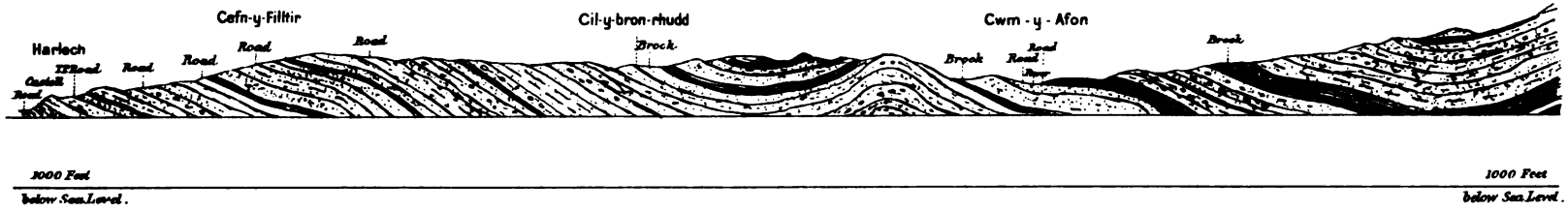
To illustrate Mr E. Halse's paper on "The occurrence of Manganese Ore in the Cambrian Rocks of Merionethshire".

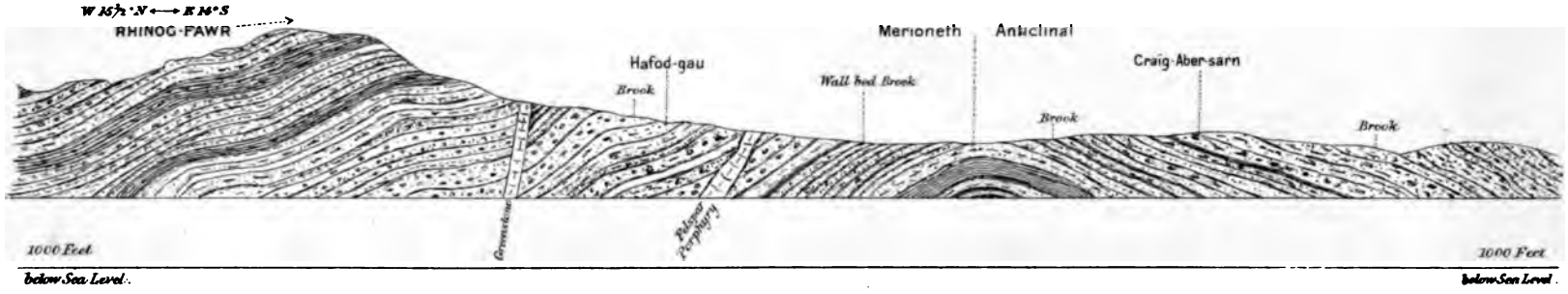
Vol. XXXVI PLATE XVI.




Llyn Bodlyn
Diphwys
MAGNETIC
MAGNETIC
A R D U D W Y
Llanenddwyn
Cors-y-gedol
Mon. Ysgethin
Llyn Irddyn
Llanddwywe
Cennant Egryn
Llanaber
Hendre Mine
BARMOUTH
Lower Silurian (Tremadoc Slates
Tingula flags &
Menevian Beds)
REFERENCE TO MAP.
Blown Sand.
Alluvium.
Cambrian Sandstone. Slate Exceptional.
Felspathic Trap Eruptive.
Greenstone.
Outcrop of Carbonate of Manganese. Bed.
Dips.
Contorted Strata.
Copper Mine.
MAP OF WEST MERIONETHSHIRE
SHOWING · OUTCROPS · OF · BEDS · OF
CARBONATE · OF · MANGANESE.
OTHER DETAILS FROM SHEETS 75 & 59 GEOL. SURV. GT BRIT.
SCALE:- ONE INCH TO ONE MILE.
Andrew Reid, Newcastle
Proceedings Nº EI of M&ME 1886-87

To illustrate Mr E. Halse's paper on "The occurrence of Manganese Ore in the Cambrian Rocks of Merionethshire".





HORIZONTAL SECTION FROM HARLECH THROUGH RHINOG-FAWR, REDUCED FROM SECTION Nº 37 OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN.

SCALE :- TWO INCHES TO ONE MILE.

To illustrate Mr. E. Halse's paper on "The occurrence of Manganese Ore in the Cambrian Rocks of Merionethshire."

FIG. 1.

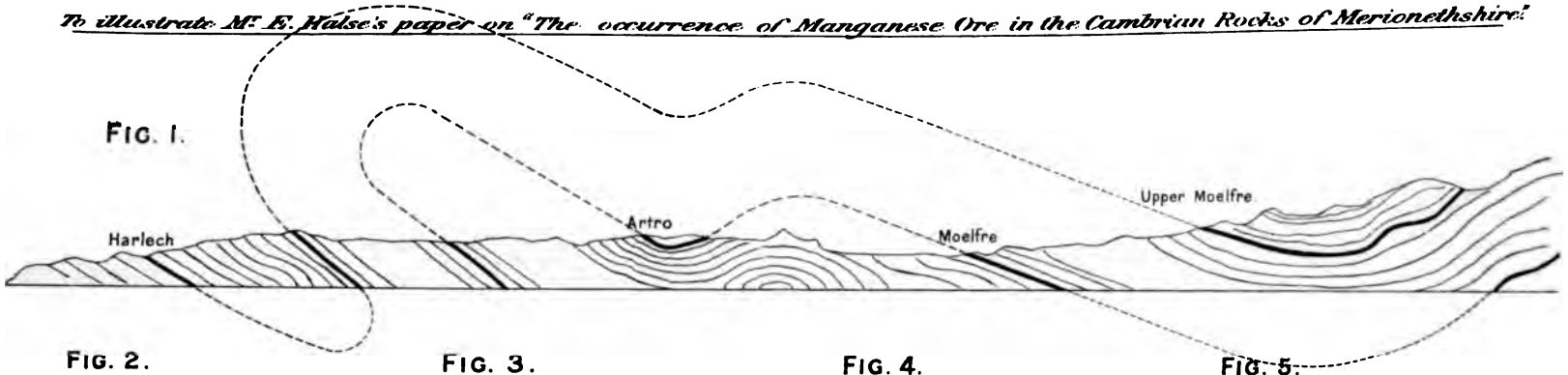


FIG. 2.

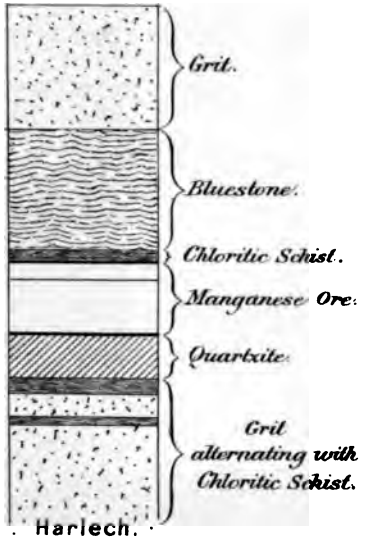


FIG. 3.

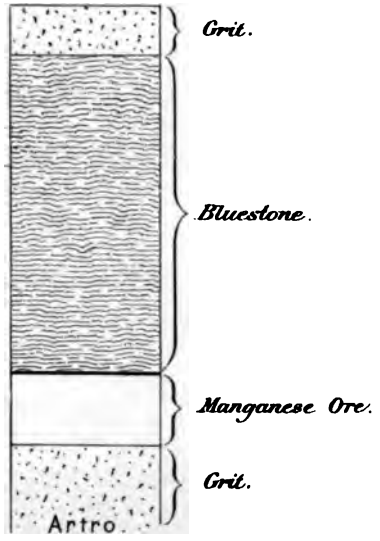


FIG. 4.

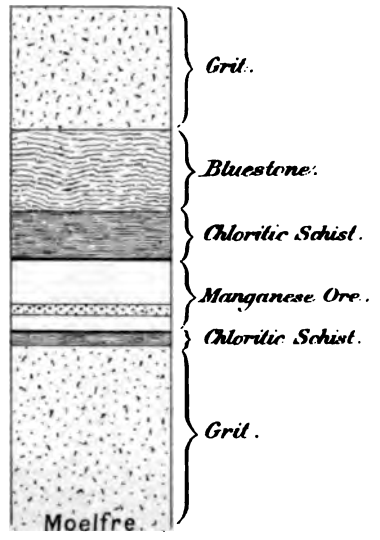
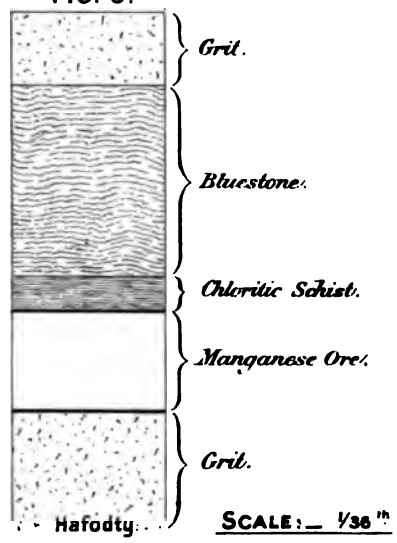


FIG. 5.



Andrew Reid, Newcastle.

...Thomas's paper on "The occurrence of Manganese Ore in the Cambrian Rocks of Merionethshire"

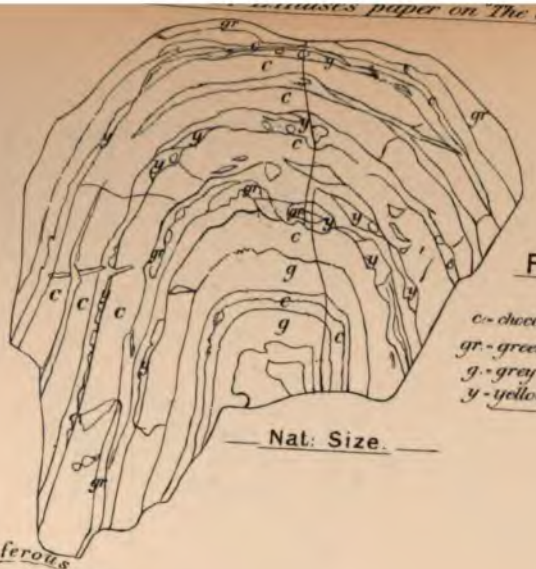


FIG. 1.

c - chocolate brown colour
gr - greenish "
g - grey "
y - yellowish "

Nat: Size.

FIG. 2.

bl - black colour
c - chocolate brown do.
g - greenish yellow do.
y - yellowish do.
gr - grey do.
st - slate do.

Nat. Size.

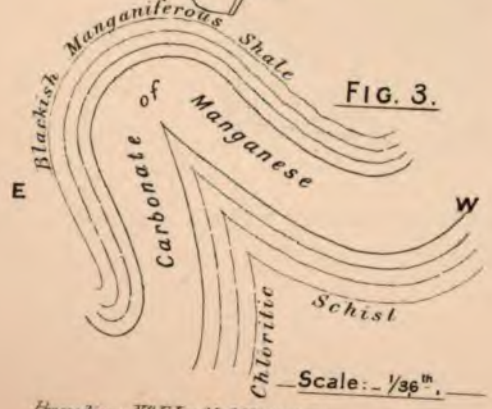


FIG. 3.

Scale:- 1/36th.

FIG. 4.

Nat: Size.

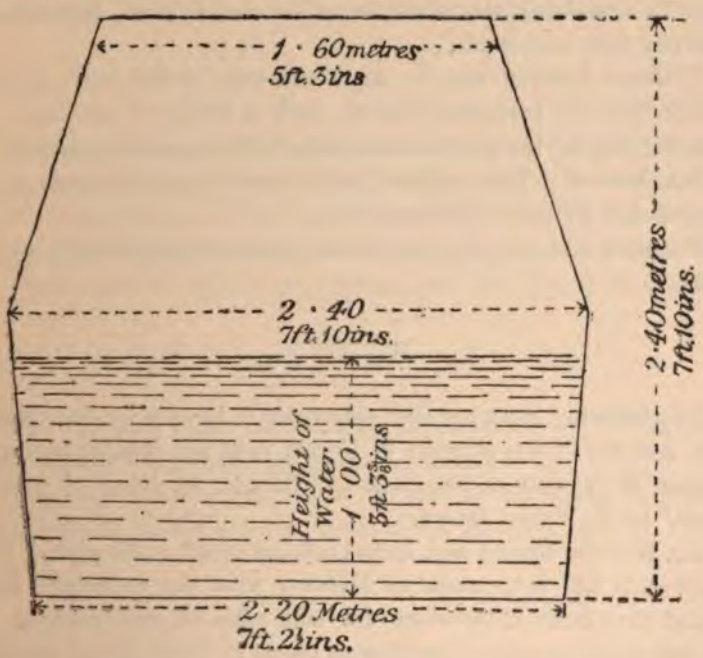
FIG. 5.

Scale:- 1/36th

Proceedings N.o E.I of M.s M.E. 1886-87.

Andrew Reid, Newcastle.

worked from adits and levels from the mountain sides, the owners have proved 600 metres of vertical height in the coal seams, and had sunk a shaft, which was descended by a sort of winding staircase for at least a depth of 40 metres below the surface for the access of workmen. Prior to Madrid being connected with the Barruela coal-field by railway, these coals were carted 25 miles to Alar de Rey, carried from there to Valadalid by canal, 80 miles, and carted from Valadalid to Madrid, 150 miles, or a total distance of 255 miles. At Orbo, although they used to draw the coal by shafts, they had spent something like £10,000 in constructing a grand underground canal about a mile and a quarter long, viz., 2,000 metres. He had tried to get the Spanish gentleman (Señor Don Mariano Zuazhabar) who had charge of the mine to write a paper for this Institute; it was still possible that he would. While in many things, and in machinery, they are behind England, they are very clever in other things. The underground canal he had alluded to had simplified very much the obtaining of access between the coal mines and the line of main railway. By this underground canal they bring the coal out in barges (containing the pit tubs), carrying about 12 tons at a time, by an endless wire rope, at a speed of one metre per second. The dimensions and shape of the canal tunnel are as follows :—



Professor LEBOUR said, he had been very pleased to listen to Mr. Marley's remarks, and to hear that he shared his (Professor Lebour's) view that the Catalonian coal-fields—there were two—were most probably a continuation of the coal-fields which lie on the southern side of the Cantabrian Mountains. The Asturias coal-field proper, on the north side of the range, were probably more closely related to those little patches of Coal-Measures which were met with on the north side of the Pyrenees, in Southern France. There were half a dozen spots on the eastern side of the Pyrenees where Coal-Measures had been proved, and many other spots where Coal-Measures might be proved in time. They were patches only, and separated from each other by spaces formed of old rocks. The question was to decide how far this barren rock extended, and how far the Coal-Measures extended. So much of the known Coal-Measures, as he showed by the diagrams illustrating his paper, were covered unconformably by newer rocks, that it was all but certain that a great deal were covered up by such beds, and could scarcely be discovered by mere surface exploration at present. A string of other coal-fields might be discovered, which would be fresh links between the Western coal-field and those of Catalonia.

Mr. MARLEY said, he alluded not so much to the Burgos coal-field, which he considered very small, as to the San Cebrian, Barruela, and Orbo coal-field in Palencia.

Professor LEBOUR said he might add that he had lately given to the library of the Institute a Spanish work in which the coal-fields were described very fairly; but the Catalonian field was scarcely described.

Mr. MARLEY—The coal-field of the province of Palencia is not mentioned in Professor Lebour's paper.

Professor LEBOUR said, he did not guarantee the information in the book.

The following paper was then announced to be open for discussion:—"An Account of Experiments in France upon the possible connection between Movements of the Earth's Crust and the issues of Gases in Mines," by M. Walton Brown.

Mr. WALTON BROWN said, he had nothing to add to his paper. Some experiments had been made at Marsden with the apparatus, which showed that earth disturbances did take place in that district. In November last a number of movements; some in December and January;

very numerous movements during the time of the earthquakes in the south of France in February; and a few in March, April and May. Sometimes there were tremors going on continuously for weeks.

The PRESIDENT—While the earthquakes were going on in the Riviera were there movements?

Mr. WALTON BROWN—Yes. Unfortunately there had been no gas tests made in the mine to see whether there was any connection between the seismic motions and the presence of gas. This was owing to the difficulty of getting a gas tester.

The PRESIDENT—What is meant by a gas tester? A measure of the pressure or quantity?

Mr. WALTON BROWN—A measure of the percentage of gas in the air of the pit.

Mr. THEO. WOOD BUNNING said, Mr. Corbett had informed him that he was carrying on a still more enlarged series of experiments at his colliery than those he had published in Vol. XXXII., as to the action of gases in the goaf, the results of which he would bring before the Institute in due time. It would be advisable for Mr. Brown to be in communication with that gentleman, for very likely the experiments he was making with gases would elucidate many phenomena which the experiments with the seismograph at Marsden might record.

The next paper open for discussion was "On the System of Working Ironstone at Lumpsey by Hydraulic Drills," by Mr. A. L. Steavenson.

Mr. STEAVENSON said, one of the latest day's work he had to record was 88 holes bored and fired in 8 hours, bringing down over 200 tons.

The PRESIDENT—Can any gentleman beat this, that is the question?

The following paper was also open for discussion:—"On Securite, a New Blasting Compound," by Mr. S. B. Coxon.

The SECRETARY thought it was the wish of Mr. Coxon to postpone the discussion, he would not say *sine die*, but for some time.

PROCEEDINGS.

GENERAL MEETING, HELD IN THE THEATRE OF THE NEWCASTLE-UPON-TYNE ROYAL MINING, ENGINEERING, AND INDUSTRIAL EXHIBITION.

SATURDAY, JUNE 11TH, 1887.

SIR LOWTHIAN BELL, BART., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting, and reported the Proceedings of the Council.

The following gentlemen were elected, having been previously nominated :—

ASSOCIATE MEMBERS—

Mr. F. H. EDWARDS, Little Benton, Newcastle-upon-Tyne.

Mr. EUSTACE SMITH, Wire Rope Manufacturer and Shipbuilder, Newcastle-upon-Tyne.

The balloting list for the Election of Officers in August was submitted to the meeting in accordance with Bye-Law 21.

Mr. GEORGE MAY conducted the members over the Haulage Department of the Exhibition and explained in detail the different systems there shown in operation.

The subject of Haulage is considered so important that it has been decided to publish a full illustrated description of the methods on view at the Exhibition, which will be issued in a subsequent part.

PROCEEDINGS.

RECEPTION OF VISITORS IN THE WOOD MEMORIAL HALL BY THE PRESIDENT (SIR LOWTHIAN BELL), THE MAYOR (SIR BENJAMIN BROWNE), MR. J. DAGLISH (PRESIDENT OF THE EXHIBITION EXECUTIVE COMMITTEE), AND OTHER MEMBERS OF THE INSTITUTE AND CITY COUNCIL.

AUGUST 3RD, 1887.

Sir LOWTHIAN BELL said he had expected a number of Chinese to be present, and that accounted for the slight delay which had been experienced. Possibly the fact of the Chinese officers not having arrived at the stated time was due to the difference between Greenwich and Pekin time. He was glad to find so good a number assembled that day in order to meet the strangers who had honoured them with their presence in the city of Newcastle. He was glad, and he was sure they would all be glad, to see the Mayor of Newcastle and the Corporation, who had kindly attended to supplement his words of welcome. He was sure the men of Newcastle would be glad that her Majesty had seen fit to confer distinction upon the Mayor, and, through him, upon their old and famous city of Newcastle. To the strangers amongst them he gave a hearty welcome to what he believed to be almost the oldest, if not the oldest coalfield in the world. He was reminded of this by his having paid a visit to a very old and respected friend of his own during the last few days—Mr. John Clayton, of the Chesters. And there he had had an opportunity, as perhaps many of them had had, of having proof of the antiquity of the Northumberland coalfield, in seeing, amongst the remains of the Roman occupation, cinders of Northumberland coal, and soot deposited during the time of their occupation. It was perhaps a consolation to think that the Romans were no more consumers of their own smoke than we were. He might say to the men of Newcastle and neighbourhood how charmed

he had been with that visit to the Chesters. His old friend had for his companion a sister whose name was never uttered in Newcastle without feelings of veneration. They both appeared to be, and were, he believed, as happy and cheerful as any in the very bloom of youth and vigour, a state which could only arise from a life well spent. Sir Lowthian explained the programme of the visit, and then called upon Sir B. C. Browne to welcome them to the city.

The MAYOR, who was heartily received, said he was exceedingly proud to have the honour, on behalf of the city of Newcastle, to give them a most hearty welcome to the city and neighbourhood. He sincerely hoped that their visit would be an interesting and enjoyable one. It was only last week that he had the honour of welcoming to the city the members of the Institution of Naval Architects, and consequently they had had visits from representatives of what were now our own greatest industries. But, while iron shipbuilding was so great an industry, Newcastle owed, probably to a great extent, its existence as a modern town to the coal trade. And, therefore, in welcoming their visitors that day, they were welcoming a body with whom they were more deeply associated than any other. It was most appropriate that Sir Lowthian Bell, as President of the Institution of Mining Engineers, and with his world-wide scientific reputation, should welcome them first, and that he (the Mayor) should, as representing the general body of the citizens of Newcastle, add his words to those of Sir Lowthian. Of course they knew that by the prosperity of the coal trade they directly or indirectly lived. If they had better times in the coal trade, not only would the mining engineers and those who had invested their money in mines, and those who worked in those mines, benefit, but the whole of the shopkeepers and tradesmen and various manufacturers in the district would receive advantage, and the landowner and the agricultural labourer would feel substantial improvement. He thought it was a fact worthy of notice that the day was gone by when a man tried to keep his knowledge to himself. In these days, scientific bodies met, and deliberated, and each profited by the experience of others, and thus they endeavoured to make the country as prosperous as possible. He considered the value of such meetings as that had been under-estimated instead of over-estimated. They could not say exactly that, because they had in the district the Naval Architects and Mining Engineers they could write down an increased value of their works, but he was convinced that such visits had a substantial effect for the better upon trade. They, in Newcastle, felt that they derived benefit from such visits, and he gave the visitors a most hearty welcome to their city.

His Worship was accompanied amongst others by Ald. Potter, Ald. Milvain, Ald. Barkas, Ald. Gray, Councillors T. Richardson, Stephens, and Birkett, and the Town Clerk (Mr. Hill Motum).

The visitors then proceeded to visit the Exhibition, where luncheon was provided.

In the evening there was a Conversazione in the Theatre of the Exhibition, attended by a large number of visitors and members with other inhabitants of the district.

On Thursday, August 4th, a number of collieries in the district were visited at the kind invitation of their respective owners,* and on Friday, August 5th, there was an excursion down the river* in the steamships "J. C. Stevenson" and "Alice."

* See Programme of Excursions given at page 201.

PROCEEDINGS.

ANNUAL GENERAL MEETING, HELD IN THE THEATRE OF THE ROYAL MINING, ENGINEERING, AND INDUSTRIAL EXHIBITION, NEWCASTLE-UPON-TYNE.

SATURDAY, AUGUST 6TH, 1887.

SIR LOWTHIAN BELL, BART., PRESIDENT, IN THE CHAIR.

In addition to members, there were also present a large number of mining and mechanical engineers from all parts of the Kingdom and the Continent, who had visited Newcastle and district on August 3rd, 4th, 5th, and 6th, at the invitation of the Institute.

The SECRETARY read the minutes of the last meeting and the Reports of the Council and Finance Committees.

The PRESIDENT appointed Professor J. H. Merivale and Mr. M. Walton Brown to act as scrutineers for the election of officers for the ensuing year.

The following gentlemen were nominated for election at the next meeting:—

ORDINARY MEMBERS—

Mr. JOHN CRIGHTON, 2, Clarence Buildings, Booth Street, Manchester.
Mr. C. Z. BUNNING, Warora Colliery, Central Provinces, India.

ASSOCIATE MEMBERS—

Mr. EDWARD MCCARTHY, A.R.S.M., 16, Sunnyside Road, Ealing, London, W.
Mr. W. C. COCKBURN, 1, St. Nicholas' Buildings, Newcastle-on-Tyne.
Mr. LANCELOT DOBINSON, Hebburn Colliery, Newcastle-on-Tyne.
Mr. WILLIAM LEE, Manager, Felling Colliery, Newcastle-on-Tyne.

STUDENT—

Mr. GEO. W. FORSTER, Heworth Colliery, near Newcastle-on-Tyne.

The PRESIDENT delivered the following Address:—

PRESIDENT'S ADDRESS.

GENTLEMEN,

Introductory. The office of President of the Mining and Mechanical Engineers of the North of England has been filled by some of the most distinguished men of their number. This circumstance naturally led me to hesitate in accepting a position which, along with great distinction, carries with it much responsibility. I must in consequence ground my hope of success in the discharge of its duties by claiming some indulgence on the part of those over whom it has become my duty to preside. The members of the Institute will kindly recollect that I do not pretend to the possession of that practical acquaintance with mining and engineering science, so useful, and as it appears to me, so necessary, for any one filling the chair I now have the honour of occupying. On the other hand I am anxious to render such help to the progress of these two branches of knowledge as can be afforded by any experience I may have acquired in a closely allied branch of industry. This is the only return in my power to make for the honour they have been pleased to confer upon me.

50 Years Progress of Local Industry. Although questions connected with the advance of the more immediate objects of our Institute have been referred to by one or more of my predecessors, the present year suggests the propriety of considering some of them in relation to events which, in an industrial as well as in a social point of view, have conferred such distinction and lustre on the period embraced in the last half century.

Progress dependent on Cheap Fuel. This selection of subjects for my Address may carry me outside of the line of thought which ought to be my guide this afternoon; but when the events themselves to which I have just alluded were only brought within our reach by the possession of unlimited resources of cheap coal

and cheap iron, there would seem to be a fitness involved in their consideration by a Society composed of Mining and Mechanical Engineers. The course I propose adopting will afford an opportunity of calling attention to the service your labours have rendered to the human race. It will also enable me to remind an audience, consisting largely of men of Northumberland and Durham, how much these two counties have contributed in raising the last 50 years so far above any corresponding period in the history of the world.

Railways 50 years ago.

In the year 1839, and therefore just short of half a century ago, it fell within my duty to undertake a journey of upwards of 10,000 miles on the mainland of Europe. To its performance nine months were devoted, and the Continent, from North to South and from sea to sea, was crossed four times by as many different routes. Before starting on this expedition from England, and during it, practically every mile of public railway then in existence was travelled over, and this did not greatly, if indeed it did, exceed 300 miles in length.

Contrast this with the 280,000 miles built since that date and fancy, if you can, the perpetual movement rushing along them. As a factor in the calculation, we had, in one year, conveyed along the 17,000 miles of line in the United Kingdom 700 millions of passengers, almost equal to half the population of the globe; and 270 million tons of goods and minerals. It is doubtful however whether these enormous figures will materially assist in forming any intelligible idea of the magnitude of the traffic carried on by a system of transport established within the lifetime of many of our members.

Neighbourhood of Newcastle, the birth-place of Railways.

Addressing you, as I have the honour of doing, in the very birth-place of the Railway, I trust our guests will pardon my dwelling for a few moments, and for a few moments only, on the part we and our predecessors have played in the development of an institution which has been attended with the results I have just claimed for it.

Railways, History of their Development.

The germ out of which the modern railway sprung was sown nearly 200 years before the opening of the Stockton and Darlington line, the first undertaking of its kind in the world. It originated with a colliery owner of the name of Beaumont in the immediate neighbourhood of Newcastle. The rails he employed were of wood, the partial use of which was continued, within my own recollection, for conveying coals to the Tyne for shipment. Cast, as well as wrought iron, had been employed for rails, but

only sparingly previous to their more general introduction in the adjoining coal-field. It was not however until 1821 that anything was heard of a malleable iron rail, rolled expressly for this purpose. In that year the Directors of the Stockton and Darlington Railway decided to lay a portion of their intended line with cast iron and the remainder with an iron rail invented by Mr. Birkinshaw of Bedlington in Northumberland. They were rolled in lengths of 12 or 15 feet and weighed 28 lbs. per yard. This was as heavy a mass as the machinery of those days could deal with; and it offers a striking contrast with the practice of the present time, when we have a united force of 7,000 horse power, turning out above 400 tons of 82 lb. rails in 12 hours in lengths of more than 120 feet.

The mechanical appliances called into existence by railways are almost infinite in their number, and some of them are most ingenious in their design; but it was the locomotive engine which proved the key to the success which was ultimately achieved. The idea of propelling a machine by steam, which in its turn should be capable of drawing loaded carriages along a railroad, was not a new one. On the contrary, it had engaged the attention of several mechanicians; but it was not until 1813 that any practical result was obtained. In that year Mr. Hedley placed a locomotive on the Wylam Colliery wagon-way which continued successfully for several years to draw the produce of Mr. Blackett's pits to the shipping place at Lemington. At this point of its history the question engaged the attention of George Stephenson who had removed from Wylam to Killingworth Colliery, where ultimately he enjoyed the advantage of the advice and assistance of Nicholas Wood, one of the founders and first President of our Institute. The first locomotive built at Killingworth by this self-taught engineer ran for years on the colliery railway, and is now to be seen, thanks to the owners of that concern, on the High Level Bridge, a highly interesting record in the history of this truly national invention.

Some few years after Stephenson had taken up his residence at Killingworth he entered into an engagement with Losh, Wilson, & Bell, formerly of Newcastle, to superintend the construction of locomotives. This modest beginning was, I believe, the first attempt to organise their manufacture on a commercial scale. It was however some years before this new form of engine could be trusted to overcome the impediment presented by even a moderate gradient. In consequence of this want of power the Directors of the Stockton and Darlington Railway, under the advice of Stephenson who had been appointed their engineer, adhered to the old colliery plan of using stationary engines and ropes,

except in cases where the country permitted the construction of the line level enough to be capable of being worked by locomotive power. Some seven years after the opening of the railway just named, Stephenson obtained the prize of £500, offered by the Liverpool and Manchester Company, for his famous Rocket engine, a model of which as well as those of other early designs may be seen in the Exhibition now open in this city. Not even the measure of success which attended the performance of this last attempt of our great local engineer sufficed to inspire the promoters of the Newcastle and Carlisle Railway with sufficient confidence to adopt it as the moving power on their line. By the recommendation of a committee, appointed to enquire into the subject, it was determined to work the entire line with fixed engines, and, in consequence, no parliamentary authority was sought for to use locomotives. Before, however, the first section of this railway was ready for public traffic, which happened in 1835, the Directors wisely abandoned the idea of ropes and opened the line with two engines built in Newcastle at the works of R. Stephenson & Co. and R. & W. Hawthorn.

Tools and Appliances 50 years ago. From the time when Hedley placed his engine, running about five miles an hour, on the Wylam Railway, to the day when Stephenson built the Rocket, capable of running nearly 30 miles an hour, seventeen years had elapsed. To understand, what now would be considered this slow rate of progress, we must recollect the means possessed by mechanical engineers 50 or 60 years ago. The iron foundries on the Tyne were incapable of making a casting exceeding a few hundredweights, and for want of the tools found now in every engineering shop, almost every kind of fitting work was done by hand. The success of a locomotive engine depends on its compactness and perfection of workmanship, so as to fit it among other things to use steam at a high pressure. All this involves an amount of accuracy which can only be secured by the admirable machine tools with which we are now so familiar.

Work turned out now and 60 years ago. If you wish to compare the character of the iron work of 1827 and 1887 you may have the opportunity of doing so within the walls of the Exhibition building, where there is placed the No. 1 Engine of the Stockton and Darlington Railway, alongside of several of the present type of locomotive from the shops of some of our leading builders. Besides accuracy of execution the workmanship of our own time has the further advantage of economy. I remember hearing from my father that the iron work of the engine erected by Boulton and Watt at Walker was charged 2s. 6d. per lb., equal there-

fore to £285 per ton; and for this high price the fittings were of the rudest description; rattling, when the machinery was at work, as if it might tumble to pieces at any moment. For about one-ninth of this rate we can now purchase a locomotive engine with a fire-box of copper and almost all its other parts of steel, built, and much of it polished with all the care necessary for forming part of a delicate instrument intended for philosophical research.

Cheap Fuel and Cheap Iron led to Construction of Railways.

I have spoken of the aid rendered in this North-Eastern corner of England to the introduction of railway transport, and nothing, it is hoped, has been claimed beyond what is due to the place and to the men who performed their duty in connection with its development with zeal and intelligence. While saying this much, it must not be denied that the circumstances of the time had rendered an improved means of communication a work of general necessity in this country. Fortunately the possession of cheap fuel, and additional discoveries at the time of ironstone, favoured the thought and afforded the material for providing the relief we required. Many individuals were labouring, and had laboured usefully, in this field; one or two names among them only have been mentioned, but the subject had taken too deep a hold of men's minds and too much had been accomplished by others, to permit a doubt to be entertained that the immediate future was destined to see the heat of former ages which lay buried in our coal-fields converted, on a largely increased scale, into motion for the benefit of the human race.

Railways on the Continent.

While a net-work of railways was gradually being extended over the face of the United Kingdom the Continent of Europe was following the example we had set. The result, as we all know, has been, that travelling, or land transport of any kind, is now rarely performed in the manner which was all but universal 50 years ago.

Railways in the United States of America.

To no nation however has the railway rendered greater service than to the United States of America. It is true nature has furnished their vast extent of territory with large means of water communication; but enormous as is the volume of such a river as drains the Valley of the Mississippi, by far the greater portion of its area, extending over one and a half million square miles, is inaccessible either by the main stream or its tributaries. This want, and others of a similar kind elsewhere, are being constantly lessened by the construction of hundreds, it may in truth be said of thousands, of miles of railways on the American Continent.

Steam Navigation a consequence of Railways.

In our own country, as well as on the mainland of Europe, in America, and now in Asia, the locomotive is bringing down the produce of the interior to the sea coast, ready to be carried over sea for the use of other populations. It is therefore not to be wondered at that steam was looked to as a means of rendering the same service on the ocean that it had afforded on the land.

Former opinions respecting Ocean Steamers.

I deemed it needless to say, in the case of railways, that there were those who, ignorant of the quantity of heat capable of being afforded by a given weight of coal, or unaware of the mechanical duty it represented, would have disbelieved the statement that 30 lbs. of coal was able to drag a train weighing 300 or 400 tons one mile at the rate of 50 miles an hour or more. To such the success of the locomotive was for a long time a matter of doubt, and with them an opinion of Dr. Lardner in reference to transatlantic steam-navigation probably had great weight. On the authority of this professor of physical science, the world was informed that it would be difficult, if not impossible, to construct a ship able to carry enough coal to be propelled by steam power across the Atlantic. It is true when Dr. Lardner propounded this doctrine Joule had not ascertained the mechanical equivalent of heat; but in the absence of any knowledge of the value of this essential factor in the calculation, it was premature to found an estimate upon the performance of an engine constructed for using heat itself as a moving power.

British Shipping. Before entering upon the few details which it is proposed to submit upon shipping, I would remind you of its extent to-day as compared with what it was 50 years ago. At the last mentioned date the tonnage sailing under the British flag may be taken at 750,000 tons, of which a little above 50,000 tons consisted of steamers. By the end of 1885 this country possessed 3,456,562 tons of sailing ships and 3,973,483 tons of steam vessels: together 7,430,045 tons. Inasmuch however as a ship propelled by steam is calculated to make 3½ times as many voyages as one propelled by wind, the actual carrying power of our mercantile fleet may be regarded as being now twenty times that which it was half a century ago; and that four-fifths of its work is now being performed by the assistance of the produce of our collieries. It will always be a satisfaction to the people of Newcastle, that the credit of proving the superiority of steam vessels for carrying cargoes belongs to their townsman Sir Charles M. Palmer. This he did some 35 years ago by building the "John Bowes" which, notwithstanding her age, continues

to perform excellent service. The enormous increase of traffic across the ocean implied in the figures just given, is, as I shall hereafter have occasion to show, in a great measure, a direct consequence of the improved mode, afforded by railways, of dealing with the traffic on land.

Modern Navigation dependent on Coal and Iron.

The numbers just quoted indicate with sufficient clearness how largely modern navigation is indebted to coal for the immense strides it has made in recent years, and although its dependence on the use of iron may not be so obvious, we are all aware that wood is now but very sparingly employed in naval architecture. Indeed its use may be said to be confined to forming the deck and lining the cabins of our ships. Let us now briefly consider what has been done in order to connect continents with each other by sea, in a manner more consistent with what the locomotive had achieved in uniting districts and nations by land than could have been accomplished by wooden ships depending on the wind for motion.

In our Exhibition there may be seen a very beautiful model showing the design of a steam engine estimated to work to nearly 25,000 indicated horse power, about to be constructed on the Tyne for an Italian ship of war. We also know that ocean-going steamers of very large dimensions have been built capable of running 25 miles in the hour—a speed equal to that of our best trains 50 years ago. The strain imparted to the hull of a vessel under such trying circumstances as those just mentioned, makes it more than doubtful whether it would have been possible to obtain the necessary strength with wood, forming as it were a hollow foundation of a comparatively weak material, to connect these tremendous forces with their work. If this view be correct in principle, the adaptation of iron for the frames and planking of our ships is a very important factor in the enormous development of steam navigation. It may be questioned whether, at the commencement of the reign of Queen Victoria, there was a single sea-going vessel of iron afloat. Thirteen years after Her Majesty ascended the throne there was built in the United Kingdom 132,800 tons of shipping, of which 12,800 tons only were of iron. In 1883 we launched in this Kingdom, 1,116,555 tons, that is, more than eight times the amount built in 1850; and of this 16,353 tons only were of wood, and the remainder of iron. I am not aware of the exact number of iron vessels now in existence, but I have estimated that in the seven years ending 1884, close on 4,000,000 tons of iron and steel had been consumed in hulls and engines by our shipbuilders. Of this weight about 763,000 tons were used in 1882, followed by about 860,000 tons in the year 1884.

Improved carrying capacity of Iron Ships. It has to be borne in mind that a great increase in strength was not the only advantage attending the substitution of iron, and afterwards of steel, for wood in the construction of our ships. The saving of weight, particularly when using the last mentioned material, is such that it increases the capacity of the vessel sufficiently to contain in the space gained more than coal enough to take her across the Atlantic. It will be interesting to review, however shortly, the other causes in addition to this which have so entirely falsified the prediction of Dr. Lardner and others.

In the early years of the engines built by James Watt it was deemed, no doubt principally on account of imperfect workmanship, inconsistent with safety, to use a piston speed exceeding 220 feet per minute. In the case of marine engines, as well as others, improved machine tools enabled our builders to obtain a much higher velocity, but this was limited by the weight and dimensions of the paddle wheels in large ocean-going steamships. This impediment to progress was removed by the invention of the screw which permits three times the rate of piston speed laid down by Watt. To follow up this improvement a great extension of boiler power was needed beyond that required by this great engineer. The use of cast iron boilers, one of which was working in my own time in Newcastle, and afterwards those built up of small plates, sufficed for the low pressure steam employed in his condensing engines. By more suitable iron used in boilers of improved construction, steam was employed at such a pressure that a vessel having a carrying capacity of 3,750 tons could land in New York, a cargo taken in at Liverpool, weighing 3,000 tons. This was enough to enable her to cross the Atlantic in 14 days with a consumption of 750 tons of coal.

Compound Engines. The capacity of steam as a propelling power depends of course on volume and pressure, and hence on the temperature of that passing through the cylinders. We all know how the dangers attending the use of steam at a high pressure have been met by the introduction of the compound system, in which, by the use of three cylinders, a great addition to the expansive force of the steam is now very largely employed. To such an extent has this been carried, that 350 tons of coal are now doing the work which formerly required 750 tons, enabling such a vessel as I have selected for illustration to carry 3,400 tons across the Atlantic, instead of 3,000 as formerly. The application of very highly heated steam has of course its limits, connected with the action of heat on the oil, etc., used for lubrication, as well as that on metallic surfaces them-

selves, when exposed to friction. Into these questions of detail it is not however necessary here to enter.

Heat evolved by Combustion of Coal.

It is not my wish to trouble you with observations on the performance of different forms of steam engines. I would rather seek to direct your attention to some of the conditions, occasionally perhaps overlooked, which ought to be observed in the generation and application of steam as a motive power.

The first step in such an examination is to consider the total quantity of heat capable of being afforded by coal of a given composition, which for our purpose we will assume to be as follows :—

Carbon.	Hydrogen.	Nitrogen.	Oxygen.	Sulphur.	Ash.	Total.
86·	5·5	1·5	4·	·5	2·5	100

The useful heat capable of being evolved by 100 kilogrammes of such a specimen of coal, by complete combustion would be :—*

	Kilogrammes.		Heat Units.		Heat Units.
Carbon, assuming all burnt to state of carbonic acid ...	86	×	8,000	=	688,000
Hydrogen 5·5 less ·5 to unite with the 4· of oxygen ...	5	×	34,000	=	170,000
Sulphur, burnt to state of sulphurous acid	·5	×	2,220	=	1,110
					859,110
Deduct heat for gasifying 24 kilogrammes of volatile	×	2,000		48,000	
Do. melting 2·5 do. of ash	×	550		1,375	
					49,375
					809,735†

Then $\frac{809,735}{100} = 8,097$ heat-units or calories per kilogramme of the coal.

Care must always be taken to secure the conversion of all the carbon into carbonic acid, and thus prevent any escaping as carbonic oxide. This is of importance, because each kilogramme of this element when burnt to the lower oxide only gives 2,400 instead of 8,000 calories which is obtained by its maximum degree of saturation with oxygen. Ten parts of the 86 escaping complete saturation with oxygen would entail a diminution of 56,000 calories in the 100 kilogrammes of coal burnt, equal to a loss of about 7 per cent. of the calorific power of the coal.

* In common with many others in this country, I always use in heat calculations French weights and the Centigrade thermometric scale. This is done on account of the greater simplicity this system affords in calculation. As the figures which follow are given by way of comparison their application can easily be understood even by those who may always apply English weights and the Fahrenheit scale.

† In this calculation, for the sake of simplicity, the heat evolution has been estimated on that capable of being afforded by the elements in the coal taken separately. The hydrogen and part of the carbon are however given off as hydro-carbon, which by combustion produces less heat than they would do taken separately. This correction would reduce the result by about 300 calories, but in such an estimate this difference is unimportant.

Loss of Heat in Products of Combustion.

My own observations would lead me to infer that the error more frequently lies in having an excess than a deficiency of atmospheric air passing through the boiler furnace. The weight of gases arriving at the chimney, with no more air than that required for perfect combustion, of 100 kilogrammes of coal (A) would be 1,286 kilogrammes ; but this would be increased to 1,414 kilogrammes (B), if, as often happens, there is an excess of air equal to 10 per cent. of the proper quantity. Let us suppose that in each case the gases have a temperature of 425° C. (797° F.) The quantity of heat in the two cases would be as follows :—

	Calories.
(A) 1,286 kilog. × 425° C. Temp. × ·24 specific heat ...	= 131,172
(B) 1,414 „ × 425° C. „ × ·24 „	= 144,228
Difference (= 9·95 per cent.)	13,056

What also frequently comes to pass is an excessive amount of heat in the escaping gases. If we assume, in addition to the excess of air in B, the firing to be so pressed that the gases arrive at the chimney 150° C. (270° F.) hotter than at A the loss will be :—

	Calories.
(C) 1,414 kilog. × 150° C. Temp. × ·24 specific heat ...	= 50,904
Add difference from excess of air in B over A, as above ...	13,056
	63,960

We have then 809,735 cal. : 63,960 :: 100 : 7·9 being the percentage of additional loss from an excess of 10 per cent. of air in the gases and 150° C. additional temperature.

In the case of A the total loss at the chimney is 16·20 per cent. of that generated, namely, 809,735 heat units.

In the case of C the total loss at the chimney is 16·20 + 7·9, or 24·1 per cent.

The observations just made regarding the air to be admitted into the fireplace must not be construed as indicating that the chemical equivalent and no more, is the quantity required for economical working. Some recent experiments rather point to an excess being necessary for securing complete oxidation of the coal. My meaning, therefore, is that whatever the proper proportion may be, anything beyond this must be regarded as a source of loss.

From irregularities consequent upon the ordinary system in firing, one cannot help suspecting some amount of variation in both the items just described. Partly to avoid this, and partly to prevent smoke, my firm, among others, has tried and continues to use automatic stoking. I regret

however to say we have experienced no economy in the fuel consumed, nor does the amount of water evaporated in boilers of similar size and with similar superficial areas of furnace bars, show any improvement over hand firing. Compactness, particularly in marine engines, being a matter of great importance, the draught is now often forced by mechanical appliances in order to increase the consumption of fuel on a given space of grate room. Attention under this new system should be paid to the character of the combustion and to the temperature of the resulting gases, so as to minimise the loss arising from these two causes in the way just described.

If we go back 120 years, when steam power was beginning to be applied to the drainage of our coal pits, the duty performed was very low, namely, about 64,000 lbs. of water raised one foot per lb. of coal burnt. The engines then used owed their motion to the pressure of the atmosphere; steam being merely employed to obtain a vacuum by its condensation, got by injecting cold water into the cylinder. James Watt effected the same end by a separate condenser and then proceeded, in addition, to work his steam expansively, by which he raised the duty to 316,000 lbs. Gradually, by means of more highly pressed steam and better constructed engines, the duty was increased to above 950,000 lbs. The researches of Black the chemist on latent heat first directed the attention of Watt to separate condensation, which, with the observation of practical engineers of great skill, constituted the only guides for improving the steam engine, until Joule's determination of the mechanical equivalent of heat in 1843. By this distinguished physicist it was ascertained that in burning a single pound of coal there was energy developed equal to raise 11,422,000 lbs. one foot high, but that the actual useful effect obtained from a steam engine and good boilers did not when he wrote exceed 1,000,000 lbs. raised one foot in height; showing a loss of 91·25 per cent. of the power of the coal. This information to the engineer is invaluable, because it enables him to realise the exact amount of his loss and also forms the key in looking for its cause.

Percentage of heat utilized at boiler. We have seen that 1 kilogramme of coal, properly burnt, is capable of affording 8,097 calories, and it will be hereafter shown that 1 kilogramme of steam having a pressure of 60 lbs. above that of the atmosphere contains 652·8 calories.

Hence, $\frac{8,097}{652·8} = 14·40$, which is the theoretical quantity of water at 0° (32° F.) capable of being converted into steam of the pressure just given by one of coal.

Such an estimate as that in question enables us to compare our actual practice with the theoretical quantity of coal required. In ordinary boilers eight parts of water converted into steam by one of coal from water at the freezing point is considered good work. The total loss may then be thus formulated :—

	Calories.	Per Cent.
8 kilogrammes of steam at 60 lbs. above atmospheric pressure (or 5 atmospheres) 8 × 652·8	= 5,222	64·49
Assume 25 per cent. loss at chimney on 8,097 calories ...	... 2,024	25·00
„ loss from carbon unburnt in ashes	... 404	4·99
Balance per radiation, &c.	... 447	5·52
	8,097	100

Another value possessed by these figures is the power they afford of disposing of certain statements made with regard to pretended improvements in raising steam. If we were told that ·3 of a kilogramme will evaporate 8 kilogrammes of water, science would reply that ·3 kilogramme × 8,097 = 2,429 calories, to do work represented by 5,222 calories besides providing losses, amounting to 2,875 calories in the case we have taken for examination.

We have now obtained our steam with a loss of or approaching to 30 per cent. of the heat used in generating it, under the above assumed conditions. Let us now proceed to consider the extent to which the heat contained in the steam is available as a source of power.

Heat in Steam at various Pressures. As is known to us all, the temperature of steam rises with its pressure, in other words the quantity of heat increases with the pressure, thus one kilogramme of steam contains at :—

	Calories.	Temp. C.	Temp. or F.	Calories in 8 Kilogs. of Water as Steam.
Atmospheric pressure ...	637°	100°	212°	5,096
3 atmospheres	647·3	134°	273·2°	5,178
5 do.	652·8	152°	305·6°	5,222
7 do.	656·5	164°	327·2°	5,252
9 do.	659·8	175°	347·2°	5,278
11 do.	662·2	183°	361·4°	5,298

Loss by latent heat in Steam. These figures indicate how small an addition of heat to that required to obtain steam at atmospheric pressure suffices to raise the pressure, say to 11 atmospheres : that is, 10 atmospheres above that of the atmosphere. This, for the purpose of preserving a consecutiveness in my story, I would remind you is due to the large amount of heat which becomes latent in the conversion of boiling water into steam, an amount which remains very nearly the same whatever the pressure may be. Thus, while 100 heat units suffice to

raise one kilogramme of water to 100° C. (212 F.), 537 units are absorbed after this, in converting this boiling water into steam at atmospheric pressure without the temperature of the steam ever exceeding that of the water from which it was formed. This of course is the secret of the value of high pressed steam, by which is meant that practically nearly every calorie added to steam of 100° C. (212° F.) is available as a source of power. Much has been done in this direction since Joule made known his investigations on the mechanical equivalent of heat. According to a paper recently read by Mr. F. C. Marshall before the Institution of Naval Architects, the economy of fuel obtained by compounding engines amounts to 30 per cent. since the year 1870. The hiding away, as it were, of an enormous proportion of the heat generated by the fuel which must be expelled from the cylinders almost without performing any effective duty, is the chief source of loss of heat in all steam engines, because the only portion of it which is available is that absorbed by the feed water returned to the boilers.

Loss by friction, etc. This loss, added to that incurred at the boilers in the manner described, together with the friction of the working parts of the machine and some escape by radiation from the cylinders and steam-pipes, accounts for the fact that out of 100 heat units afforded by our coal in Joule's time, 10 only were useful for actual work.

Air Engines. It was to avoid this loss that Ericsen and others suggested and built engines to be driven with heated air. The amount of pressure which can be commanded, even at a temperature as high as 480° F. (177 C.), is however so small, that the machinery for utilizing it must have unmanageable dimensions.

Value of Coal in the Arts. When to the service rendered by coal in cheapening transport on land and sea, we add its indispensable aid in almost every branch of industry, nothing more need be said to justify the position I claimed for it in the opening sentences of my Address.

Exhaustion of coal. Although the existence of this mineral treasure in our immediate neighbourhood was known to the Romans, it may be estimated that one-half of the entire output got from the field up to this time has been worked during the last 25 years, so rapid has the recent increase of the demand on its resources been.

Having regard to its ascertained extent, unless its boundaries are enlarged by some unexpected discoveries, which is more than problematical, we or our successors, must begin before long, to prepare for a diminished produce and increased cost.

Substitutes for coal. It is true Dr. Lardner told us, 40 years ago, to be under no apprehension in respect to our position when our national beds of coal became exhausted ; for he assured us that the operations of nature afford abundant hope of a substitute being found ; electricity and hydrogen gas got from water however being the only ones he specified. Mr. Mulhall repeats this opinion as regards electricity, in 1880,* alleging that this agent is *already* supplying the place of coal. He seems however apparently to disregard the fact, that nearly in every case, the electricity was being obtained by burning coal under the boiler of a steam engine.

Every one who has bestowed a thought on the operations of nature, referred to by Dr. Lardner, knows the sun to be the source to which they owe their existence. The potential rays of this luminary continue, as they did in pre-historic ages, to dissociate the elements of the carbonic acid of our atmosphere, leaving their immeasurable energy transferred to the numberless forms of vegetation which cover the face of the earth. The same power creates currents of air and raises the water of the ocean to the summits of mountains. Thus we have the heat which split up carbonic acid into its elementary constituents ; which rarified the air and evaporated the water, capable of being returned to us in the form of motion ; or, if we choose, such motion may be reconverted into heat by means of suitable appliances.

When however we set to work to consider the adaptation of the operations of nature as they are taking place under our eyes, we shall find that enormous periods of time or vast areas of space are involved in their application. It has been estimated that thousands of years were needed to produce the beds of coal which were formed beneath the surface of this and the adjoining county. The charcoal, capable of being grown in a year on an acre of land, would only suffice to propel one express train over a distance of 25 miles; and for making the pig iron annually produced in Great Britain, a forest of 42,000 square miles would be required. As regards the movements in our air, Jevons calculated that it would take 1,000 wind-mills to drive a modern rail-mill. This would mean lines of these engines extending over something like 20 miles, and all to be connected with the fly-wheel shaft of the rolling machinery. The collection of the rain which falls over a large area of country into rivers affords, it is true, a ready means of concentrating its power at one point. The advantage thus placed at our disposal is obtained at a sacrifice of that

* "Progress of the World," p. 68.

portion of the force represented by the descent of the water from the more elevated and often less extensive parts of the field which is drained. Let us suppose that in order to secure the necessary volume of water the barrier of interception is placed 50 feet above the sea level at high tide. If we assume the annual rainfall over the entire acre to be 3,000 tons, and none being lost by evaporation or otherwise, the whole to fall over the height just referred to, we should have a yearly mechanical force of 336,000,000 foot pounds. This, according to Joule's investigations, after allowing 30 per cent. loss of power for friction in a water wheel, would only represent 20·6 lbs. of coal; but we have seen that in one way or another 90 per cent. of the power of coal may escape in its application; hence, the 3,000 tons of water collected on an acre of land in one year, would, in falling from an altitude of 50 feet, afford in available power, after deducting this loss of 90 per cent., an equivalent of that obtainable from 206 lbs. of coal burnt under the conditions already described.

It would be easy to calculate the amount of energy capable of being derived from impounding tidal water. The result however would only resemble, in its general outlines, that afforded by the examples already given.

There are, it is true, certain cases in which the heat required has to be generated under conditions where its cost practically forms no element in the calculation. The almost instantaneous evolution of heat of high intensity such as is necessary for explosives, or the supplementing of intense temperatures by the energetic chemical action afforded by electricity, may be cited as examples in point. As regards the latter the improved means by which motion can be converted into electric heat, may appear to justify the opinion of Dr. Lardner, and encourage the hope, often repeated since his time, that this agent may take the place of our coal after the exhaustion of our beds of this mineral. If the object to be gained were the dissociation of carbonic acid and the possible fusion of the separated carbon into a diamond, instead of moving a railway train at the rate of 50 miles an hour, at the cost of 1d. per train mile for fuel, there might be room for argument. Clearly no such cases as those just referred to affect in any way the question before us, which in point of fact is as follows:—We now possess coal occurring under such circumstances that an acre may contain 20,000 tons or more, out of which a collier can hew for his day's work as much as will make two tons of pig iron, or move a railway train weighing 300 tons over a

distance of 300 miles at the rate of 40 miles an hour. The problem therefore before us is to estimate the position of a nation, no longer possessing a material so easily obtained and endowed with so much potential energy as coal, compared with other nations having unlimited resources of this mineral at their command.

There are those who attach some weight to chemical action as being able to supply us with electric heat, and with it, electric power, when our coal is exhausted. All this however, as far as our present knowledge enables us to see, means a previous expenditure of heat. A common source of electricity generated by chemical action is the oxidation, or burning as it may be termed, of some of the metals, of which zinc is the one in most common use. This as well as others, if ever they existed in nature in the metallic state, have, since then, become oxidized. To fit them therefore for undergoing this process a second time, heat must be employed, and this is generally accompanied with great and unavoidable loss, which, along with other expenses connected with their production, forbids our looking for any assistance in their direction.

Quite as extravagant as the use of zinc, was Lardner's idea of employing the hydrogen of water as a source of heat. Water, being simply burnt hydrogen, as much heat would be absorbed in separating it from its oxygen of combination as it is capable of yielding by burning it a second time. We might therefore as reasonably expect a wheel to raise to the level of the buckets receiving the water, all that which had served to move it, as to obtain heat from the hydrogen of water, or worse still from chalk, as was insisted on by the Rev. W. Moule.

What has been said in reference to the use of electricity as a source of motion, or even of heat, to which may be added that of light, must not be considered as of universal application. Thus there are situations in Alpine countries where continuous supplies of water descending rapidly from great heights could, by means of turbines, furnish enormous power. This power could, by the aid of electricity, be transmitted to a distance as is now done by compressed air in our coal mines or still more frequently by hydraulic machinery in the manner first proposed by Lord Armstrong. For the utilization of the power on the locality where it is easily obtained from the fall of water, we need not wait for further discoveries in electrical science to assist us in turning it to useful purposes. It must always be more economical to employ the power *direct* so as to avoid the loss, as far as possible, arising from the friction which is inseparable from the delivery of mechanical energy for actual work.

It has also been suggested that electricity may be a convenient agent

for accelerating the comparatively slow movement of the ordinary steam engine into one of very high velocity. Engineers will have to consider whether this cannot be done more easily in the way proposed by the Hon. C. A. Parsons of the firm of Clarke, Chapman, & Parsons, of Gateshead, who has succeeded in constructing an exceedingly ingenious engine driven by steam, which it is said, with a very moderate consumption of coal, makes 10,000 revolutions in the minute, and can, we are told, work up to the astounding speed of 30,000 revolutions.

Natural Gas and Oil. There have been found in nature, as every one knows, vast stores of liquid and gaseous hydrocarbons which are being extensively employed as a source of heat. With these we need not concern ourselves, because, so far as exhaustion goes, oil springs and gas wells will be subject to the same laws as those which obtain with coal.

Importance of economizing Coal. With the facts and figures just given before us, instead of spending time and money in searching for substitutes for the fuel now in common use, we would act more prudently in looking for means to reduce a waste, which, when mechanical power is the object to which it is applied, amounts, as it often does, to 90 per cent. of the capacity of the coal. A considerable proportion of this waste is due to friction, a diminution of which would probably be as applicable to the steam engine as to any other *source of motion.*

Value of Iron. Not inferior as a national calamity to exhaustion of our coal would be the want of iron. Without this metal, coal, at the depths it is often found, would be beyond our reach; or, if reached, we should frequently lack, commercially speaking, the means of utilizing the object of our search. That the loss of this mineral would extinguish the manufacture of iron is proved by the experience of the last century; for in 1740, owing to the woodlands near the works failing to afford the necessary supplies of charcoal, the make of iron had declined until it did not reach, in that year, the quantity produced in one of our modern furnaces. From this threatened annihilation Abraham Darby's success in the application of coke for smelting iron ore relieved us. The production of cheap iron may, for some centuries, be considered as dependent on our being able to command cheap coal; because the known deposits of ore are too extensive to render it necessary to concern ourselves about their exhaustion.

The extent to which iron has assisted in the enormous development of our national industry is evidenced by the large increase in its use. Fifty years ago the annual consumption per head of our population was under 80 lbs. In the year 1884 it amounted to nearly 290 lbs., while the

average of the whole world was only a little above 30 lbs., and among some hundreds of millions of people it is under half a pound.

In the year 1837 the make of pig iron in Great Britain was a little above 1,000,000 tons. Since that date, namely, in 1882, it was close on 8½ millions. This great and rapid progress in production was not confined to our own country, for between 1879 and 1883 the world's output of pig iron rose from 14,000,000 to 21,000,000 tons.

Very great changes in the processes connected with the manufacture of this metal in its various forms have no doubt promoted its extended consumption in recent years. At the same time it must be allowed that our knowledge of the metallurgy of iron 50 years ago, was sufficiently advanced to have enabled us to supply the metal then, of a sufficiently good quality, and at a sufficiently low price, for the purposes for which it was wanted. In addition to the extensive but somewhat expensively worked deposits of ironstone of South Staffordshire and South Wales, Scotland had been proved to contain a large quantity of Black Band ironstone, while Cumberland and Lancashire gave good promise of being able greatly to add to their yearly output of rich hematite ore. In the works, the puddling process, although a laborious operation, had been brought to a state of great perfection and the value of the hot blast in smelting had been sufficiently demonstrated.

Recent Improvements in Manufacture of Iron.

The twenty-five years after 1837 added however greatly to our information connected with the manufacture of iron. The existence of the great Cleveland bed of ironstone, and subsequently that of Lincolnshire and Northamptonshire had been discovered, and the processes known as the Bessemer and Open-hearth for making steel had been invented. During a few years following 1862 the Middlesborough iron-masters, by an enlargement of their furnaces, and by raising the temperature of the blast from 315° as recommended by Neilson to 537° C. (600 to 1,000° F.), added to an extended use of the escaping gases, had effected a saving of one-third of the coal required to produce a ton of pig iron. Immense improvements in rolling-mill machinery and ameliorations in the Bessemer process, have so reduced the cost of making steel rails, that this article, made from ore brought from Bilbao in Spain, has been sold for what, 60 years ago, would have been considered but a reasonable price for pig iron obtained from native ore. Without troubling you with unnecessary details in the manufacture of iron I may be permitted to say that, within my own recollection, to make a ton of iron rails, beginning with the ore, about 7½ tons of coal was consumed, and now a ton of steel rails does not require above 3½ tons of fuel for its production.

This great economy in the manufacture of steel, combined with its superior strength and malleability, has led to its extensive use for purposes in which wrought iron was formerly employed. At present, nearly half the malleable form of the metal produced in this country is obtained from the Bessemer converter or from the Open-hearth furnace, and the change is one which is gradually extending.

The increase of strength in steel as compared with iron just referred to, has very much assisted in combining great power with lightness in the construction of the modern steam engine. A striking example of this is to be seen in the Exhibition where the actual machinery, capable of developing an indicated power of 1,750 horses, weighs something under 26 tons. To this proof of power in resisting enormous strain may be added that afforded by the use of steel in the heavy guns from the Elswick works and elsewhere. On the other hand the malleability of this form of iron, and its simplicity and consequent economy of manufacture, are such that the large boiler plates, also to be seen in the adjoining building, can be sold at about one-third of the price charged for iron plates of similar dimensions.

Basic Process. I would here in connection with the steel trade refer very shortly to a question of local interest. As those acquainted with the properties of iron know, that phosphorus unfits the pig containing it for either of the new modes of manufacture. So hurtful is this element, that its presence to the extent of one part in one thousand of the metal, would cause its rejection by the steel manufacturer. Now our local iron from the Cleveland Hills usually contains seventeen times more phosphorus than the quantity just named, and thus we have been compelled to supplement the purer hematite of the west coast by large importations of ore from abroad, chiefly from Spain, in order to supply the constantly increasing demands for Bessemer and Open-hearth steel. It was proved by M. Grüner, of Paris, that it was the acid properties of silica which prevented a second acid, like the phosphoric, being carried off in the siliceous slag, generated during the operation. By neutralising the acid properties of the silica by means of lime, the obstacle to the formation of a compound containing phosphoric acid was removed. This constitutes what is well known as the Basic process; but this adaptation of pig iron containing phosphorus for steel-making may however have an importance beyond that of a purely metallurgical character.

Phosphorus in Basic process as a Manure. This element has long been recognised as an indispensable ingredient for animal life; its presence therefore in our food is a necessity from which

there is no escape. The proper vehicle through which this phosphorus can be conveyed to the animal kingdom is through the vegetable. Continuous crops removed from the soil, in time exhaust its store of phosphorus, and this needs renewal which is done by the familiar use of manures. It is alleged that the phosphorus contained in the "Basic slag" is capable of being assimilated by plants, so that we have a substance which depreciates the market value of the phosphoric pig iron of our country to the extent of 10/- per ton, converted into a source of positive wealth.

Origin of Improvements in Manufacture of Iron. It has been my endeavour, in what I have said, to bring under your notice, how our abundance of coal and our great resources of ore have enabled us to produce cheap iron. Incidentally I referred to the date of the substitution of pit coal for charcoal for smelting the ore; to the invention of the puddling process; to the introduction of the hot blast; to the great enlargement of our blast furnaces; and to the discovery of new processes for making steel. Let me now add, that not only have these changes greatly reduced the cost of the metal, raised its value and enabled its production to be continued in Great Britain, after increased population would have rendered this impossible, but the improvements themselves with the exception of the Open-hearth process, were originated on British soil by British minds.

Effect of Steam Power on Trade of World. In these days of competition and particularly in these days of commercial depression, there is a tendency not only to compare the natural resources of different districts and of different nations, but to compare how the relations of each may have been affected by such great changes as those which have arisen with the extended use of steam power.

Food Importation. It is unnecessary to dwell at any length on the importance to the human race of a cheap and plentiful supply of food. This, in a country with a fertile soil, a favourable climate and a population well within the number it can feed and clothe, affords no cause for anxiety. Such however is, and for a long time has been, far from the position of the United Kingdom. In the absence of any records respecting our own agricultural produce, it would be impossible to speak with any correctness, to the extent of our home production of the necessaries of life. So recently as 47 years ago, Porter stated that "Great Britain could never obtain the bulk of her food supply from abroad, as all the shipping in the world would be insufficient to carry what her population required." This writer, were he alive, would be surprised at the extent to which we are now dependent on foreign nations for food, and at the ease with which our own shipping alone conveys it to this country.

Effect of Corn Laws on Prices. For some years before our corn laws were repealed, and in some cases after their repeal, the legislature raised the price of all articles of food to the consumer, either by forbidding their importation or by imposing a duty on articles grown on a foreign soil. In consequence, during the decade ending 1820, the average price of wheat was 87s. 6d. per quarter, after which, in more peaceful times, 60s. was a common value. With the extension of railways in the United States and elsewhere, combined with low sea freight and free trade, the price gradually fell until it reached 35s., and recently it has been even lower than this.

Cost of Living Abroad and in the United Kingdom. So long as the necessaries of life were much cheaper in other countries than with us, the workman abroad was able to maintain himself and family much more economically than could be done here. In consequence foreign labour was to be had on more favourable terms than it was with us. This was notably the case on the continent of Europe where men were plentiful and imported labour unnecessary. Matters were different in a new country like America where the inducement of high wages had to be offered to attract immigrants ; but this impediment to cheap production was met in the New World, more or less entirely, by the facilities offered in the acquisition of land.

The establishment of railways on shore, and steamers on the sea, has naturally had a tendency to equalise the cost of living in all countries; and, as a result, wages have risen considerably during later years in France and Germany which are our great manufacturing competitors. The American corn growers have, by this change, been placed in a position to include these two countries as customers for their agricultural produce. The French and German farmers however, thinking it unreasonable that they should be exposed to the competition of corn grown in the western hemisphere and yet not able to buy an American plough without paying duty, have induced their respective governments to impose an increased restriction on imported corn, the duty on wheat entering Germany being now 30s. per ton and 40s. for what is brought into France. Belgium, it is said, is preparing to follow this example, which is one calculated of course to raise the cost of labour and, with it, the cost of all manufactured produce.

Imports of Food. In order to show how the British consumer has benefited by the importation of articles of daily use, I have prepared tables from the Government returns, showing the increase in the quantities brought and retained for domestic consumption in this country, for certain years since 1840.

TABLE SHOWING WEIGHT OF MATERIAL IMPORTED AND RETAINED IN THE UNITED KINGDOM FOR HUMAN FOOD OR FOR FEEDING CATTLE, ETC.

	1840.	1855.	1865.	1875.	1883.	1885.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Live animals	Prohibited.	30,600	116,520	115,200	174,490	120,800
Bacon and ham ...	310	10,000	34,350	120,660	184,750	185,970
Beef	Prohibited.	7,750	11,250	10,750	54,700	57,090
Dead meat, salt and fresh—various ...	...	...	...	15,800	44,160	56,420
Pork	1,470	10,200	11,100	13,300	18,800	19,180
Lard	5	5,900	6,800	27,000	42,650	43,560
Fish	Prohibited.	10,250	23,600	38,700	64,480	66,190
Eggs	5,530	5,560	20,310	41,350	51,720	55,900
Butter	17,630	16,360	50,950	71,440	113,710	118,640
Cheese	11,320	18,100	41,300	80,290	88,640	91,060
Corn and flour ...	830,070	1,085,500	2,371,610	5,359,110	7,506,100	7,141,640
Rice	22,190	77,900	28,530	339,290	387,350	122,800
Onions	...	...	...	42,370	67,170	88,440
Potatoes	110	2,900	40,350	234,800	257,450	115,000
	888,635	1,281,020	2,756,670	6,510,060	9,056,170	8,282,690
Summary—						
Animal food and fish...	1,785	74,700	203,620	341,410	584,030	549,210
Eggs, butter, and cheese	34,480	40,020	112,560	193,080	254,070	265,600
Corn and vegetables ...	852,370	1,166,300	2,440,490	5,975,570	8,218,070	7,467,880
	888,635	1,281,020	2,756,670	6,510,060	9,056,170	8,282,690

If, as has been supposed, the quantity of the articles given in the preceding table and those grown in the United Kingdom, corresponded in later years in weight with those imported, we have roughly 8½ million tons of food as the produce of the United Kingdom. This gives 9,38,8000 tons foreign and home-grown as the quantity consumed in 1840, ending with 16,782,000 tons in 1885.

FOOD CONSUMED IN UNITED KINGDOM.

	1840.	1855.	1865.	1875.	1883.	1885.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Imported, taken at	888,000	1,281,000	2,756,000	6,510,000	9,056,000	8,282,000
Supposed to be grown at home...	8,500,000	8,500,000	8,500,000	8,500,000	8,500,000	8,500,000
Total	9,388,000	9,781,000	11,256,000	15,010,000	17,556,000	16,782,000*
Estimated population	26,487,000	27,821,000	29,861,000	32,749,000	35,611,003	35,941,000
Weight required per 1,000 inhabitants	354	351	377	459	493	467
Percentage of increase or decrease since 1840 ...	100	99	106	130	139	132

* It is assumed that these quantities are exclusive of grass, hay, and straw.

These figures must be taken as some indication of the great increase in the consumption of the necessaries of life which have, by a great reduction in the price, been placed within the reach of those in this country to whom cost determines the rate of consumption.

A similar conclusion is arrived at by the figures contained in the following table also taken from the Board of Trade returns:—

CONSUMPTION PER HEAD OF IMPORTED ARTICLES IN THE YEARS SINCE 1855 ARE GIVEN BELOW, FOLLOWED BY SOME OF THE ARTICLES ALREADY GIVEN IN THE IMPORTS.

	1855.	1865.	1875.	1883.	1885.
Cocoa, lbs....	1·16	0·13	·30	·36	·40
Coffee, „	1·29	1·02	·98	·89	·90
Tea, „	2·28	3·29	4·44	—	—
Currants and raisins, lbs...	1·62	4·12	4·29	4·47	4·12
Sugar, lbs.	29·22	37·17	62·85	71·74	74·28
Tobacco, „	1·09	1·31	1·46	1·42	1·45
Wine, gals.	·23	·40	·53	·40	·38
Spirits, „	·96	·94	1·30	1·06	0·97
Malt, bush.	1·24	1·74	1·95	—	—
Beer, British, gals. ...	—	—	—	27·12	26·85
Bacon and hams, lbs. ...	·96	2·67	8·26	10·96	11·47
Eggs, No.	3·58	12·23	22·62	26·40	27·56
Butter, lbs.	1·79	4·02	4·92	7·18	7·15
Cheese, „	1·53	3·17	5·46	5·51	5·48
Corn, „	53·16	93·38	197·08	250·77	235·79
Rice, „	2·18	5·72	11·68	12·45	7·57
Potatoes, „	·07	3·04	16·05	16·17	7·06

Effect of improved transit in United Kingdom and other Countries.

In what has preceded it has been sought to demonstrate the extent to which our own country, by the improved modes of transit afforded by coal and iron, has been enabled to receive cheap supplies of food from foreign nations. As compared with the countries from which these supplies are drawn, our industry may be considered as burthened with the cost of carriage. This upon the 8½ million tons may be taken approximately at an annual charge of 12 to £15,000,000 sterling. On the other hand, had these increased importations been interdicted, our population must have remained in 1885 what it was in 1840. Objections have been, and are still being, raised to certain collateral effects of the low prices at which these importations are brought in competition with the products of our own soil. Time forbids any attempt to speak at length of these, and the subject is only alluded to as being part of a very complicated system of international commerce of which some subsequent mention will be made.

Reference has also been made to the benefits conferred on our home industry, by the amelioration in our internal means of transport. In this it is obvious that the advantage to a nation's commerce from this cause will, to a certain extent, be proportionate to the area of its territory. Great Britain, in comparison with its population and manufactures, being the smallest in point of size of any country in the world, was less dependent than any other on the improvements in question for the development of its producing powers.

Thus in France and Germany the coal has to be conveyed to the iron ore, or the ore to the coal, over greater lengths of railway than intervene between the two minerals in England or Scotland. In the United States this prevails to a striking degree, for there we often hear of journeys of 500 and even 1,000 miles having to be performed, in order to bring these raw materials together, and almost everywhere the distances of the manufacturing centres from the sea are usually very much greater than with us. In the United Kingdom the distances which separate ore and coal are sometimes only 30 miles and rarely exceed 100 miles. In addition the improvements connected with the production of iron have, as we have seen, been accompanied by great economy in the consumption of coal, a change which, for the reasons just given, has proved of greater advantage to foreign manufacturers than to our own. On similar grounds there is no doubt that the Basic process for making steel has proved much more beneficial to France and Germany than it has been to us in the country where it was invented.

The long continued depression in our trade generally, accompanied by a retrograde movement in the volume of some branches of it, has given rise to much apprehension among political economists as well as among others more directly concerned in our commerce. This feeling has naturally been aggravated by the knowledge, that while our products were declining in amount, those of certain foreign countries were advancing. Among the conclusions arrived at is an inferiority in point of education to that of our competitors of other nationalities. This I believe to mean a deficient scientific education on the part of those connected with the direction of our industrial operations. Well! there is no denying that Germany in particular recognised sooner than we did the importance of education among all classes, as the only safe ground upon which national progress could be founded. We have only to consult the dates of the literature on mining and metallurgy to learn how much earlier than ourselves, not only the Germans, but the Swedes, French, and Belgians occupied themselves with a scientific consideration of the questions

involved in the cultivation of these arts. We have, it is true, made considerable progress in this direction in recent years; but I am not prepared to say that the same amount of importance is attached to, and the same general proficiency in scientific knowledge prevails with us as are to be found elsewhere. From this state of comparative indifference and from this condition of comparative ignorance, if they exist, we must emancipate ourselves with the least possible delay. We have harvested all the fruit we can calculate on gathering in the absence of that guide which science can alone supply, and for the maintenance of our industrial position we must turn to scientific instruction or be content to remain behind in the race.

It cannot however, I would submit, be maintained with any justice that the British manufacturers, at all events those whose work is of a kind with which we are familiar in the North of England, are now indifferent to scientific education. How can we, were it otherwise, account for the existence and flourishing career of such Societies as the Institution of Civil and that of Mechanical Engineers; of the Institutes of Iron and Steel; of Chemical Industry; and, not least among the number, the Institute of Mining and Mechanical Engineers of the North of England, the oldest among several in other parts of the kingdom devoted to the science of mining, etc.?

Skill of British Artisan.

Besides the fears which have been expressed with regard to the ability of those who direct our workmen, some alarm appears to be felt respecting a supposed decline in the proficiency of the artisans themselves. I shall leave the defence of those engaged in branches of industry with which I am but imperfectly acquainted to others; but in regard to those connected with the use of iron and steel I would invite a careful inspection of the workmanship displayed in the objects to be found in our local Exhibition, as an unanswerable proof of the groundlessness of these apprehensions we have to listen to from time to time. I am not going to deny that I have myself heard, from judges of undoubted capacity, of the high class of foreign workmanship as compared with some of British origin; but it has always been a question in my mind whether inferior work, purchased here at a low price under the influence of excessive competition, has not been contrasted with that of a better paid description produced in foreign workshops.

The official statistical abstracts of our exports however, furnish the best answer to this imaginary decadence of skill on the part of our workmen. In 1870 the value of the machinery sent to foreign countries

from our shores amounted to £5,273,273. In 1880 it had risen to £9,263,526, and in 1883 to £13,433,081; the average of the five years ending 1885 being £11,696,574; and all sold in markets in which the competition of the whole world had to be met.

Foreign Competition. The arguments made use of in reference to the undoubted manner in which our position as a manufacturing nation is being contested by other countries, seems to proceed too much on the assumption that we possess an intuitive genius for industrial work not found in other nations; and, relying on this, we are losing our rank by a neglect of those educational measures which may end in our having to resign to, or at least to share with, others, the honours we have for some years enjoyed.

As a matter of fact, the Dutch, Flemish, Germans, and French, a couple of hundred years ago, were to a great extent our teachers in the manufacturing arts. Even in iron, which owes so much to British enterprise for its subsequent development, the Germans, up to the middle of the last century, taught us nearly all we knew, including the use of the blast furnace itself. The possession and early knowledge of the existence of large deposits of fossil coal enabled us to revive our moribund manufacture of this metal upon which all other industries depend. While the four nations named above were distracted by the presence of large bodies of armed men, engaged in almost incessant conflict, our manufactories, unhampered by actual war in our midst, made rapid progress.

This progress, after the establishment of peace in 1815, with almost the entire world for our customers, was continued for many years. In the meantime, fresh coal discoveries were being made on the continent of Europe as well as in America, and eventually, any difficulties in rendering these new resources available, by reason of situation, were overcome as we have seen, by the introduction of railways and other improvements. The manufacturing energy was revived in the Teutonic and Latin races in Europe, and that of the Anglo-Saxons was transplanted to and flourished in America. As a result our example has been followed and our experience rendered useful, and in some cases improved, by those whose competition we have now to face. Such was the activity throughout the world that, as we have already seen, the annual increase in the total make of pig iron was 50 per cent. between the years 1879 and 1883, namely from 14 it rose to 21,000,000 tons. In this struggle for supremacy we lost, in relative advance, the position which we had occupied probably for the last 100 years. Between 1870 and 1883 the increase of our production was only 31 per cent. while that of the other nations amounted to 138 per cent.

At the same time we still remain the largest makers of iron in the world, the chief producers standing for the year 1886 in the following order:—Great Britain, 6,870,665 tons; United States, 5,683,329 tons; Germany, 3,489,400 tons; France, 1,507,850 tons; Belgium, 697,100 tons. The make of this country it must however be remarked fell from 8,493,000 tons in 1882 to the figure just given.

The rapid increase in the case of Germany and Belgium has compelled these two nations to become exporters to the extent of fully one-third of their united make. It may appear extraordinary that being protected from importations from Great Britain by the cost of the transport, and the further protection of import-duties, that these countries meet us in neutral, and indeed in our home markets, with something like 2,000,000 tons of iron annually, upon which they have generally more to pay for carriage than we have, and upon which they lose the advantage afforded by the import duty. There are indications that a position of maximum consumption of iron has been reached in our own country, inasmuch as the quantity, including that used for machinery exported, has remained pretty stationary during the last dozen years, fluctuating between 3 and 3½ million tons. On the other hand, our exports of iron have decreased to the extent of about 1,000,000 tons annually.

These figures, taken alone, may well lead the British public to fear that their own iron makers may be failing either in intelligence or in energy, or in both. This is not true; no nation, taken as a whole, possesses greater natural advantages for the successful pursuit of this branch of industry, and of its advantages Great Britain makes as good a use as any other people do of theirs. It has to be admitted that during the last few years not only has our production fallen off, but what we have made has left little, or in many cases no profit to the manufacturer; but in this respect we do not appear to be worse off than our neighbours. According to a published list, out of 18 works engaged in manufacturing and mining operations connected with iron in Germany, only two made a profit exceeding 10%; eleven varied from ⅓% to 4½%; and seven realised no profit or made an actual loss.

Education in Northern Coal-field of England.

Before concluding this Address, I would, with your permission, add a few words on what has been done, and is doing, in the cause of education in this locality. If, as must be allowed, not an inconsiderable progress was made in our works and mines with little help from a knowledge of physical science, we ought in any retrospect, to consider our failures as well as our successes. If this were done, we should find many instances of labour and money having been wasted for want of a proper guide to

direct us in our course. But whatever the result of such a stock-taking of the past might be, I think I am justified in the assertion that we all here believe the day has gone by for us to trust longer to guess work and the time-honoured rule of thumb. This I hope is our opinion entirely irrespective of any fear of competition from foreign nations, who after all, were we their superiors in any particular point would speedily adopt our improvements as we have imitated theirs. Those of us who are old enough to remember the period when such learning as that in question was regarded by some with disfavour and almost by all with indifference, can, by the light of our experience, compare the past with the present. We would wish, as the result of this experience, to warn the rising generation and especially would we warn those entrusted with the care of it, of the irremediable difficulty to which its members will be exposed, on being placed in positions which then will, and can only, be properly occupied by those who have been prepared by previous training. This is not a light which is dawning on Newcastle for the first time. Within the walls of the Literary and Philosophical Society, one of the earlier formed institutions of its kind in the land, the Reverend William Turner, half a century ago, laboured to inculcate a love of natural science. By our fathers and grandfathers the Museum of the Natural History Society was founded which was enriched by the exertions of Hutton, by Alder, by Albany Hancock, by Athey and others, and the crown has been placed on the institution by my old and distinguished friend John Hancock. Not only has he, by the munificence of the Joiceys, by that of Lord and Lady Armstrong and other friends, been enabled to erect one of the best buildings of its kind in the kingdom, but he has presented to it a magnificent collection of ornithological specimens, the fruit of a long life devoted to the cultivation of science.

I would also mention a name held in high esteem on Tyneside, I mean that of Hodgson, the historian of Northumberland, who first called the attention of Sir Humphrey Davy to the appalling calamities accompanying the then very frequent explosions in our coal mines. With his own hands he collected the specimens of gas used by Davy in examining its properties, and his own life was the first exposed to danger for the purpose of demonstrating the value of the safety-lamp in the dark recesses of a coal mine.

College of Physical Science in Newcastle.

This reference to our great local industry suggests the propriety of claiming the merit to which we as an Institution are entitled in connection with promoting the cause of scientific education. At its first meeting thirty-five

years ago, and by its first President—Nicholas Wood—the necessity of providing a suitable school for scientific instruction was earnestly insisted upon. I believe I am the only survivor of a small committee which was subsequently appointed to consider the recommendation of Mr. Wood. I am not going to trouble you with an enumeration of the difficulties we encountered beyond saying that money, or the want of it, was very far from being the least. This at last was sufficiently met by our former President Mr. Edward F. Boyd succeeding in enlisting the sympathies of Dean Lake the Warden of the University of Durham and his colleagues on the council of that body. As one of those who had an opportunity of witnessing the earnestness with which Mr. Boyd devoted himself to the work, I would venture once more to place on record to-day the invaluable assistance afforded to us by the University, obtained in a great measure through his intervention.

Some question has been raised as to the amount of success which has attended the labours of our College. I believe sincerely this has been as great as the means placed at the disposal of its Council entitled any one to expect. Notwithstanding the difficulties entailed upon the professors, for want of the necessary accommodation, nearly 500 students attended the classes during the last session. Of these about one-fifth received instruction by actual work in the chemical laboratory. Out of former students, it has been ascertained that more than 150 have become mining engineers, and of these, about 20 have found employment in India, in our colonies, and in foreign countries. With these results, and with the growing necessity for properly educated superintendents for mines and manufactories, the governing body felt they had no alternative but to proceed with the erection of a suitable building for carrying on the work which they have taken in hand. This step, rendered unavoidable by the loss of class rooms, once more compels the Council to renew an appeal for public support. A large sum will be needed in order to retain the services of the present excellent staff of professors and to meet the expenditure necessary for placing the establishment on the footing its merits and importance demand. This appeal is addressed not only to those who are directly interested in the object for which the College has been created, but to the principal landowners, as well as to every resident in the North of England who cannot be dissociated from what best promotes the public good of the district.

It will be for the students, for whose special advancement and benefit the Durham College of Science at Newcastle has been founded, to show

the measure of their appreciation of its objects by a diligent application to those branches of knowledge which will be taught within its walls.

While recommending an institution like the College at Newcastle to public support, I would have it understood that I am not insensible of the good work which is being done in what, so far as scientific teaching is concerned, may be regarded as excellent preparatory schools. Among these, although there may be others, I would mention the Newcastle Grammar School, and that in Bath Lane, (for which latter the town is chiefly indebted to Dr. Rutherford,) the Grammar Schools at Durham and Darlington, and the High School at Middlesbrough.

M. V. DAIX, Ingénieur des Mines, Constructeur-Mécanicien, Chevalier de la Légion d'Honneur, à St. Quentin, France, addressed the meeting as follows:—

MESSIEURS,—je n'ai jamais, autant qu'aujourd'hui, regretté de ne pas savoir l'Anglais d'une façon suffisamment correcte pour prononcer un discours; car, pour la mission qui m'a été confiée, j'aurais voulu me faire bien comprendre de vous tous.

J'ai, en effet, Messieurs, à vous remercier, non seulement de l'invitation que vous avez bien voulu adresser aux ingénieurs étrangers d'assister à votre meeting, mais encore de l'accueil gracieux et bienveillant que vous avez fait a ceux qui ont pu se rendre à votre invitation.

En venant dans le Nord de l'Angleterre, nous savions fort bien, Messieurs, que nous y serions bien reçus, et cela pour un double motif: tout d'abord, le travail rend les hommes meilleurs, elle les rend bienveillants pour les étrangers; car c'est lui, le travail, qui est le grand précurseur de la paix; et, sous ce rapport, votre région, Messieurs, est une des plus priviligiées, c'est une de celles où le travail est le plus en

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GENTLEMEN,—I have never regretted so much as I have to-day my inability to speak English in a sufficiently fluent manner to enable me to address you in that language; for that which I have to say I would wish to be comprehended by you all.

I have in effect, gentlemen, to thank you, not only for the invitation which you have been so kind as to give to engineers of other countries to attend your meeting, but also on account of the gracious and courteous welcome you have given those who have been able to avail themselves of your invitation.

On coming to the North of England we felt sure we should be well received, and that for two reasons. First, work makes men better and more courteous to strangers, for work is the great precursor of peace, and in this respect, gentlemen, your district is one of the most privileged, for it is one of those where work is most honoured. It

honneur ; il suffit de parcourir, comme nous l'avons fait hier, la Tyne depuis Newcastle jusqu'à l'endroit où elle se jette dans la mer pour se rendre compte de l'activité industrielle de cette région du Nord de l'Angleterre. Les usines, les établissements industriels s'y succèdent si rapidement qu'on ne sait vraiment où se termine la ville, et qu' on se demande si elle ne s'étend pas depuis ici jusqu'à l'embouchure de la Tyne.

D'autre part, Messieurs, Newcastle nous était bien connue, la réputation de vos pères est faite et le respect filial, si en honneur parmi vous, est tel que les bonnes traditions ne se perdent pas. Or, en parcourant la route si mouvementée qui conduit de la Central Station à l'Exposition on rencontre, vers le milieu, le Monument que vous avez élevé à la mémoire du Earl Grey. Pour honorer ce grand citoyen qui fut longtemps premier ministre, vous avez signalé en première ligne que pendant les cinquante années qu' avait duré sa carrière politique, il avait été constamment l'avocat, le défenseur de la paix.

Vous voyez donc bien, Messieurs, qu'en venant ici, nous savions y trouver des amis, mais votre excellent accueil a dépassé nos espérances et je tiens à vous dire que ceux de vos invités qui n'ont pu se rendre ici éprouveront un double regret : celui de n'avoir pu admirer les choses splendides que vous nous avez montrées et celui plus vif encore de n'avoir pu apprécier votre excellent accueil.

TRANSLATION.

is sufficient to go, as we did, down the River Tyne, from Newcastle to the spot where it throws itself into the sea, to be enabled to comprehend the industrial activity of this region of the North of England. Factories and industrial establishments succeed one another so rapidly that it is impossible to say where the town of Newcastle finishes, and one asks oneself whether it does not extend from where we sit at present to the mouth of the Tyne.

Secondly, gentlemen, Newcastle was well known to us; the reputation of your fathers is established, and filial respect so much in honour amongst you, is such, that your good traditions will not be lost. Indeed, in passing along the streets so full of life, which lead from the Central Station to the Exhibition, one sees about midway a monument which has been erected to the memory of Earl Grey. To pay honour to this great citizen, who was for a long time prime minister, you have placed prominently before the world that during the fifty years of his political career he was constantly the advocate and defender of peace.

You will readily understand then, gentlemen, that in coming here we were well aware that we should find friends ; but your very warm reception has exceeded our hopes, and I would especially remark that those gentlemen who were unable to accept your invitation will experience a twofold regret—first, in not having been able to admire the splendid collection of objects which you have shown us, and, secondly, what is even more to be regretted, not having been able to feel the warmth of your excellent reception.

Nous qui, plus heureux, avons pu venir, nous garderons précieusement, Messieurs, le souvenir des grandes et belles choses que vous nous avez fait voir : vos charbonnages si parfaitement organisés, vos usines si bien installées et si admirablement conduites ; nous aurons longtemps devant les yeux les magnifiques Iron-works de Jarrow, si puissamment outillées comme force et comme production et l'admirable organisation des Tyne Docks, où, par suite des dispositions intelligentes qui ont présidé à leur organisation, 20,000 tonnes de charbon peuvent, chaque jour, être chargées dans des vaisseaux qui vont porter au loin le nom de l'Angleterre en général et celui de Newcastle en particulier.

Nous n'oublierons pas non plus, Messieurs, l'organisation si belle de votre exposition, qui se distingue tout particulièrement par les travaux pacifiques qu' elle fait admirer, par le classement si intelligent du groupement des appareils, par la division raisonnée de l'éclairage électrique où tous les systèmes sont si bien représentés et si bien installés, et surtout par le caractère spécial et éminemment pratique de ce qui touche à la science de l'Ingénieur et à l'Art des Mines. Je signalerai plus particulièrement ce qui est exposé dans la partie Nord des Jardins: les modèles des mines de charbon, de plomb, et les essais de traction à l'intérieur des mines.

Cette partie de votre exposition, Messieurs, est caractéristique, jamais encore on ne l' a vue nulle part ; les dispositions prises font ressortir la valeur pratique des Ingénieurs et des Industriels qui l'ont organisée, et je

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We on the contrary, who more happily have been able to come, will well guard the remembrance of the great works which you have enabled us to see. Your collieries so perfectly organised ; your factories so well arranged and so admirably conducted ; we shall have for a long time before our eyes, as a vision of force and production, the magnificent ironworks of Jarrow, with its powerful machinery ; also the admirable organisation of the Tyne Docks, where, as a consequence of the intelligence which directed their construction, 20,000 tons of coal have been shipped per day in vessels which carry to all parts of the world the name of England in general and of Newcastle in particular.

Neither will we forget, gentlemen, the splendid organisation of your Exhibition, which may be considered particularly to excel in those peaceful works to which it invites admiration, by the intelligent classification and grouping of systems of machinery, by the scientific way in which all the systems of electric lighting have been placed, and, above all, by the specially practical way in which all that has reference to the science of engineering and the profession of mining has been displayed. And I would especially draw attention to the models of coal and lead mines, together with the numerous systems of traction suited for the conveyance of coal in the interior of the mines, as exhibited in the North Gardens.

This part of your Exhibition, gentlemen, is unique ; nothing like it has been seen anywhere ; and the way in which it has been carried out shows well the practical knowledge of the engineers and manufacturers who have organised it, and I have no

crois pouvoir affirmer ici que cette organisation d'essais pratiques faits en grand servira de modèle aux organisations des expositions futures.

Au nom des Ingénieurs étrangers presents, mais encore au nom de ceux qui n'ont pu venir, je vous remercie, Messieurs, de votre invitation et de votre si excellent accueil.

Je ne puis m'adresser spécialement à ceux d'entre vous qui nous ont plus particulièrement accueillis, je craindrais en agissant ainsi de laisser croire que tous vous n'avez pas été bienveillants; et, sous peine de me créer des inimitiés alors que je désire n'avoir en vous que des amis, je devrais vous citer tous. Je remercie donc tous les industriels qui nous ont reçus avec tant de bienveillance, je remercie tous les membres de l'Association des Ingénieurs Miniers et Mécaniciens du Nord de l'Angleterre dans la personne des deux honorables gentlemen qui les ont représentés si dignement et qui nous ont particulièrement si bien accueillis; j'ai nommé votre honorable président Sir Lowthian Bell et votre honorable vice-président M. William Cochrane.

TRANSLATION.

hesitation in stating here that this exhibition of practical methods of transit made on such a large scale will serve as a model for all similar undertakings in future.

In the name, therefore, of the engineers visiting here, and further in the name of those who have not been able to come, I thank you, gentlemen, for your kind invitation and for your most excellent reception.

I cannot address myself specially to all those amongst you who have been most pressing in their attentions, lest I should be thought to infer that you had not all been equally kind; and therefore, to avoid creating foes where I only desire to find friends, I thank all who have received us, and I thank all the members of the North of England Institute of Mining and Mechanical Engineers in the persons of the two honourable gentlemen who have represented them so well, and who have received us so well, namely, your worthy president, Sir Lowthian Bell, and your worthy vice-president, Mr. William Cochrane.

Mr. M. H. MILLS, of the Chesterfield and Midland Institute, said he wished to say a few words as a member of the Council of the Chesterfield and Midland Institute in thanking the members of the North of England Institute for the very great hospitality which they had received during their visit to the North of England. He was quite sure when they returned home every one of them would hunt out particulars to try if they could find strains of north country blood among them, and so be enabled to lay claim to connection with the north country people. He thanked the North of England Institute on behalf of his Institute. He was sorry

that none of the vice-presidents of the Chesterfield and Midland Institute had been able to stop till to-day, having been obliged to go home.

Mr. JAMES C. HUNTER said, he also had great pleasure in thanking the North of England Institute on behalf of the Geological Section of the Naturalist Field Club of Barrow-in-Furness. His colleagues and himself, when they returned home, would be able to tell of the hearty and hospitable reception they had during their visit to the meeting.

Mr. T. W. EMBLETON said, he had hoped that he would have been left to sit silent, and that he would have been able to conclude his visit to his native town without being called upon to make a speech. As President of the Midland Institute of Mining, Mechanical, and Civil Engineers, he thanked the North of England Institute for the very hospitable way in which the visitors had been received. He had been pleased to visit his old native city to see the improvements which had taken place since he went southward sixty years ago. About 70 years ago the banks of the Tyne were covered with wood. At that time the only public conveyances between this city and Shields were the "Shields Gig" by land, and the so-called "Comfortable" by river. The latter mode was very inconvenient, and not unfrequently the "Comfortable," drawing about three feet, was stuck on the Hebburn sand for hours. Now the banks are covered with manufactories of every description and ships of the largest burthen can reach the works of Lord Armstrong & Co. miles above the Swing Bridge.

Mr. J. S. DIXON said that, as President of the Mining Institute of Scotland, he also had to thank the North of England Institute for their invitation and the entertainment which had been provided for them. He was glad to be present to return thanks on behalf of the visitors for the great kindness they had received, and the great amount of instruction they had got from visiting the splendid collieries in this neighbourhood.

The PRESIDENT said, he would assure those gentlemen who had spoken how very gratifying it was to the Council and members of the North of England Institute to hear that their endeavours to render the stay of the visitors here not only useful, but agreeable, seemed to have been entirely successful. He would convey the kind messages, particularly of M. Daix—whose speech would be translated into English, and be published in the Transactions—to the Executive Council of the Exhibition.

Mr. JOHN DAGLISH said, that in rising, unexpectedly as he did, he was sure he would have their entire sympathy in proposing a vote of thanks to the President, Sir Lowthian Bell, for the very valuable and interesting Address which they had had the gratification of hearing. The

world-wide eminence of Sir Lowthian made it sure that the Address would contain matter, not only of interest for the moment, but suggestive for the future. The Address would form a matter for serious consideration with all of them after this meeting. He proposed a vote of thanks to the President for his Address.

Mr. GEORGE B. BRUCE (President of the Institution of Civil Engineers) said, he was not a member of the North of England Institute, but if a stranger in that sense might be allowed to second the motion just proposed, he would have great pleasure in doing it. He had come to the meeting with the special object of hearing Sir Lowthian Bell's Address, and he was sure they would all read it over very carefully. There was one part of the Address to which he had listened with considerable interest, and that was the portion in which Sir Lowthian referred to the danger they were in of being overmatched in their competition with foreign nations. He thought it was true what was said by Sir Lowthian as to the absolute necessity of their taking care to see that technical education was followed up in this land in a way that it had not hitherto been. He could not help feeling that the English had something in them besides education. He did think they need not look at education in a spirit of despair in comparison with other nations. There was a degree of spirit and energy he held in the English people—it might be a national prejudice on his part, he did not know—which enabled them, in spite of defects in education, to work under great difficulties. He remembered when he was making a railway in Germany, and the contractor was English, and had an English engine-driver. According to the German law, the engine-driver must pass an examination. Jack could not pass an examination in English, much less in German; and so the contractor was obliged to have a German driver on the locomotive. The contractor found he was then not getting a sufficient amount of work out of the engine, and said, "This will not do," and he put the English driver back on to the footboard to do the work, and the other man remained also as engine driver in the eyes of the law. The contractor paid both men rather than not have the work go on. It was not education in that case that succeeded. Let them get education; but do not let them seek it in the spirit of despair, as if other nations were overcoming them. He had very great pleasure in seconding the vote of thanks to his old friend, Sir Lowthian Bell, and was very glad to be back in this old town where he was born, and see an old school-fellow sitting as President.

The vote of thanks was agreed to.

The PRESIDENT said he was very much indebted to the two gentlemen who had proposed and seconded the vote of thanks. He must express the hope that his old school-fellow and friend, Mr. George Bruce, did not imagine he was at all afraid of the position which the English were capable of taking in the race of nations. All he had wanted to impress on the meeting was, that the English had got very formidable competition to meet, and that if they wished to compete successfully they must keep abreast of other nations in the matter of education. If any one told him Englishmen were falling behind other nations, he would ask for his company for twenty-four hours, and would take him down to see the Forth Bridge, and would ask, "What do you think of English engineers after what can be there seen?" He had just learned that there had now been 1,000,000 visitors to the Exhibition. As they were on the subject of technical education, he would recommend all employers of labour, and others who were interested in the intellectual progress of those with whom they were associated, to take a very early opportunity of sending their workmen to the Exhibition, in order to avail themselves of the scientific education to be gained there.

The SECRETARY read the following paper on "The Federation of the Mining Institutes of Great Britain":—

THE MINING INSTITUTIONS OF GREAT BRITAIN.

HAVE the mining engineers in the United Kingdom any institution sufficiently well organised to effectively represent their interests in that quarter where these can best be promoted? and, if not, what steps had best be taken to have them so represented? are questions the solution of which this paper is intended to facilitate.

The mining engineers are a numerous and influential body of men. They have the superintendence of the extraction of nearly 180 million tons of minerals, of the value of from 50 to 60 million pounds. They have established various societies already in different parts of England and Scotland, and although none of these can be said to be more than provincial associations, yet, nevertheless, some of them are of very considerable importance. But, up to the present time, no effort has been made to found a universal society in the metropolis; the result is that the mining engineers are not represented as a whole, and, therefore, that their influence is divided and weakened.

Another very great inconvenience of the present arrangement is that the transactions of each society often contain papers which have been read before other societies, and that a mass of useful information is divided and rendered difficult to refer to, as it is not indexed in one collection, each separate portion having only a limited circulation.

The mining operations of England and Scotland are spread very unequally over the two countries. For the sake of convenience in considering the subject, the total output has been divided into six local districts, each represented by one or more mining associations, all of which freely enrol other classes of engineers to membership. (See Table 17.)*

1.—*North of England,* which raised in 1886 about 44 million tons of minerals. This district is represented by the "North of England Institute of Mining and Mechanical Engineers," which has 16 members

* Proofs of all matter referring to the various Institutions mentioned in this paper have been sent to their respective Secretaries, and appear as corrected by those gentlemen.

and a total income of £39 for every million tons raised in the district it represents. (See Tables Nos. 1, 2, and 15 in the Appendix to this paper.)

2.—*The Midland Coal-field*, which produces about 60 million tons, is represented by two societies, one "The Chesterfield and Midland Counties Institution of Engineers," and the other "The Midland Institute of Mining, Civil, and Mechanical Engineers," which, combined, have nearly 6½ members and a total income of about £9 for every million tons raised. (See Tables Nos. 3, 4, and 15.)

3.—*Staffordshire District*, producing about 19 million tons, represented by two associations, the "North Staffordshire Institute of Mining and Mechanical Engineers," and the "South Staffordshire and East Worcestershire Institute of Mining and Mechanical Engineers." These, together, have 24 members, with a total income of £16 to every million tons raised. (See Tables Nos. 5, 6, and 15.)

4.—*Scottish District*, producing 24 million tons, represented by the "Mining Institute of Scotland," having 18½ members, with a total income of about £16 10s. for every million tons raised. (See Tables Nos. 7 and 15.)

5.—*South Wales*, producing 31 million tons, represented by "The South Wales Institution of Engineers," having 11·3 members, with a total income of £25 16s. for every million tons raised. (See Tables Nos. 8 and 15.)

6.—*Cornwall*, producing half a million tons, represented by the "Mining Institute of Cornwall," having 484 members, with a total income of £620 to each million tons raised, the produce in this case being mainly metalliferous ores, not coal. (See Table No. 9.)

The British Society of Mining Students.—It is difficult to decide under which district to put this very useful institute, and therefore it has not been classified under any, but taken by itself. It is a very important body, which should be and is the very back-bone and recruiting-ground of all the others. Its papers are generally excellent. It has 232 members; 2 are free honorary members, 61 honorary, 41 senior, and 128 subscribing members. The subscription of honorary and senior members is 10s., and of other members 7s. 6d. per annum.

This society publishes its proceedings in a very excellent form, has an income of £87 from its subscribers, with arrears amounting to £23 12s. 6d., or about 27 per cent. of the sum paid by the members. Its balance sheet is given in Tables Nos. 10 and 11.

In addition to these there are various other bodies, such as the Manchester Geological Society, which are more or less occupied with

mining subjects, but those institutions already described are considered sufficient to illustrate the subject.

It will be seen that the districts are very unequally represented. To what extent this inequality exists practically and otherwise than on paper would require to be decided by some one who has a more intimate knowledge than the writer of the nature of the mining operations carried on in the various centres; for instance, although Cornwall as a centre seems to produce very little mineral, still it has comparatively a large number of members, and a by no means insignificant income for the quantity of the mineral raised, which is of very great value; whereas probably the largest district of all, which possesses two institutions—one of which is of considerable importance—has only 6½ members to every million tons raised, and has a comparatively low income.

Perhaps the most prosperous of all these institutions is that in the North of England. This may possibly be accounted for by the fact that it was the first to commence its work in a district which may almost be said to have inaugurated coal mining, and which at the time was thought the most considerable mining centre in England, and this caused it originally to be joined by many leading men from the other districts, who do not like to forsake it even where other societies have been formed nearer to them.

The unequal proportion of the numbers of members in the various societies to the districts which they respectively represent is, however, a matter of very great importance, since it may cause much dissension should the views advocated in this paper ever be discussed. This portion of the subject ought not to be passed over without the remark that the mineral owners—the influential possessors of the soil—do not seem to be adequately represented in any of the societies above enumerated. Before anything like a strong central association could be even thought of, the assistance of the majority of these gentlemen should be obtained. They are very deeply interested, and their membership would materially strengthen the position of any society to which they belonged.

Referring to Table No. 15, it will be seen that there are in the eight institutions mentioned above 2,584 members, with a total income of £4,085; the income from members being £3,533, and the total amount of arrears £1,285—that is, 36 per cent. of the income received from members is still standing over for collection. It must not, however, be supposed that the whole of these 2,584 members represent the same number of different individuals; because, by an examination of Table No. 16, it will be seen that a great number belong to more than one institution.

The North of England Institute has in other societies	118	members.
South Wales, besides the members which it has in the above society, has in other societies	16	„
Midland, do. do.	17	„
Chesterfield and Midland Counties, do. do.	3	„
Scottish	1	„
Making a total of	155	„

Which number, subtracted from the 2,584 given before, reduces that number to 2,429. This shows that if all the mining engineers at present enrolled in provincial societies were to be all members of one society, they would form a very numerous and powerful body of men, much more likely, than as now, to command the co-operation of the mineral owners. London is, no doubt, the centre of attraction for most professional men, and members would travel long distances to attend meetings there who would not go to any other town, however large, because in London there is very frequently some other business to attend to, and in that city more influential people are met and additional opportunities of professional employment are presented. Besides, London, especially in the spring, is the focus of all Parliamentary work; and if any impression is to be made on Government, or any inquiry to be made or important matter to be reported upon, London is the place in which to do it. This is peculiarly the case with the mining interest, which is so continually being interfered with by Government.

It may be said, however, that there will be many and formidable difficulties to overcome before any such society could be successfully established in London. This is no doubt true, although it might not be expected from the experience of the Mechanical Engineers, which body succeeded in organising their London offices without having to overcome many serious difficulties, because the change involved no loss of money or sacrifice of property, for they were not tied to Birmingham by possessing a large or expensive establishment.

Many of the mining and engineering societies mentioned above have already spent large sums of money in providing handsome buildings for their accommodation, and have collected extensive libraries, which they would be unwilling to forsake; and as they have considerable local influence, it would be difficult to induce them to break up their societies to form one larger in London. Nor would it be advisable to do so, even if it were likely that they would agree to the change, for mining, unlike mechanical undertakings, is confined to the place where mineral is con-

tained in the soil, and is not spread over all England like mechanical engineering; and as each district has its peculiar modes of working and varieties of minerals, it is most advantageous to have local societies where these can be discussed amongst those engineers who are especially connected with them. It would therefore seem that the only way to induce members to found a society in London would be to preserve the autonomy of the district societies, and have a general federation of the whole in London.

Although it may not appear at first sight that London is a mining centre, yet it contains many professional gentlemen deeply connected with copper, lead, gems, and the precious metals; and before, or at the same time, that the federation of all the societies in London is carried out, it would probably be advisable to have a local London institution, called, for instance, "The Mining Institution of London," devoted specially to this class of mining, and taking the same general position towards the federated society as does each one of the country centres.

Again, the writer's experience shows that there are many Englishmen in India and the Colonies who take a considerable interest in several of the local institutions, and who contribute to them most valuable information. If the new federation were established, it is more than probable that colonial centres might be formed, and a very valuable mass of information in the shape of papers might be read and discussed in the place where all the facts connected with the papers are known, and sent up for publication to the federated society, which might in a few years take up a very important position, not only in England, but wherever mining operations are carried on.

It would be as well, perhaps, here to pass in review two existing London societies—"The Institution of Civil Engineers," and the "Institution of Mechanical Engineers"—as types, first, of what a society should be which represents all classes of engineering, and, second, what a society should be which represents one class only.

The Institution of Civil Engineers embraces all classes who are engaged in "the art of directing the great sources of power in nature for the use and convenience of man," and this definition allows it to take in nearly everybody. To become a member, however, of this very powerful body requires a man to possess a considerable amount of skill, and the honour is eagerly sought and tenaciously held; so much so that it is rare for any member to be in arrears of payment, and in their balance sheets the word is almost unknown. Being a member gives considerable advantages of a pecuniary and professional nature, as both foreign and English

projectors seek amongst its ranks suitable persons to carry out their enterprises, and choose them as arbitrators in their disputes.

The annual subscription to the Institution is, for—

	£	s.	d.
Resident Members	4	4	0
Non-resident do.	3	3	0
Resident Associates	3	3	0
Non-resident do.	2	12	6
Resident Students	2	2	0
Non-resident do.	1	11	6

New members and associates pay an entrance fee of £10 10s.

This society had, on the 31st March, 1886, 20 honorary members, 1,542 members, 2,111 associate members, 501 associates, and 926 students, making a total of 5,100. The income from annual subscriptions was, for the twelve months preceding the date named, over £13,000, of which the arrears only amount to £376, or not 3 per cent. of the sum actually received as subscriptions. (See Table No. 12.)

The Institution of Mechanical Engineers, which has been located in London now for ten years, and which is taken as a fair type of the second description of societies, viz., those which represent *one* particular branch of engineering science, has been very successful. Many of its members are also members of the older institution. It has—

		£	s.	d.
5 Honorary Members.				
1,511 Members	at	3	0	0
34 Associates	„	3	0	0
124 Graduates	„	2	0	0
Total 1,674 Members,				

with a total income from subscriptions of £4,359. The arrears amount to £423, or about 9 per cent. of the sum actually received as subscriptions. (See Table No. 13.)

The relative importance of the two societies may be put thus:—

	Members.	Associates.	Students.	Subscriptions.		
				Paid.	Unpaid.	
				£	£	
Civil Engineers	1,542	2,612	926	13,195	376	3 %
Mechanical Engineers ...	1,511	34	124	4,359	423	9 %

There is also a significance with regard to the item of arrears which is perhaps more important than at first sight would appear, for irrespective

of the money lost to a society it is a proof that the membership is not highly esteemed, and that its members are *recruited* to a certain extent with difficulty, the honour of admission not being sought for with such ardour as would prevent them from dropping off at the first convenient opportunity.

The arrears of these two societies, as given above, amount to 3 and 9 per cent. of the total subscriptions paid, whereas by looking at Table No. 15, it will be seen that in some local mining institutions they amount to more than half the subscriptions paid.

It is true that among the provincial societies there is one bright exception to be found in the Mining Institute of Scotland, the amount of arrears there not even amounting to one per cent. This is due to the fact that the rule as to cutting off members who are one year in arrear, and not carrying forward such arrears, is strictly adhered to, and the arrears shown in the abstract of accounts in each year are the arrears of the preceding year only.

Taking the total amount paid in subscriptions and the total amount of arrears due in all the eight societies quoted above, the arrears amount to about 36 per cent. of the amount of money obtained from members during the year.

This seems to be the most powerful argument that possibly can be adduced in favour of having a central society, of sufficient power and influence to make it the interest of every mining engineer to belong to it, and when once admitted a member to stand by it; for it is evident, from the amount of arrears shown to exist in the present local societies, that the honour of membership is not sufficiently appreciated, and that very many more mining gentlemen would belong to a powerful society than at present belong to the numerous smaller societies that are spread over the kingdom.

The mining engineers could not expect to have a society of the importance of the Institution of Civil Engineers, who, as before stated, embrace all classes, but they might reasonably hope to have an organisation which would equal, if not exceed, that of the Mechanical Engineers, in the number of its members and in its income, were they united and had their head-quarters in London.

It has been before stated that the difficulties the Mechanical Engineers had to overcome in moving to London were of a much lighter character than those which would have to be overcome by the various mining associations were they to form one central society; in fact, if the forming of a central society meant doing away with the local societies it might be

safely conceded that the change would be impossible. The only way, therefore, that seems open to consideration is whether a federated association could not be formed, called, perhaps, "The Imperial Mining Institute," which would in effect create a perfectly new society in London, with which the whole of the present local societies should be affiliated.

As neither of the two large London establishments before described are affiliated with any local ones, it will be necessary to seek such information as may be available in order to see how a federation could be accomplished. The only society which seems to offer some points of similarity to what has just been suggested is the Society of Chemical Industry, which, although only recently started, has nevertheless been exceedingly successful. The general meetings of the Council of this society are held in the offices in London; it has eight provincial sections, viz., at Birmingham, Bristol, Glasgow, Liverpool, London, Manchester, Newcastle, and Nottingham. All subscriptions are paid into the general fund, out of which the provincial expenses are paid. The Publication Committee sits for six months in London, and for six months in Manchester, where the journal is published and printed. This committee examine all the sectional papers, which, however, together with the discussions, have already been revised by the local revision committees and endorsed by the local secretaries. There are 2,300 members, who pay 25s. each, and, although the Society is of recent formation, its finances are in a highly prosperous condition. Each section has its own president, council, and secretary; meets where it thinks proper; and can provide extra funds to the extent of 5s. from each local member, but hitherto the local expenses have been all paid out of the central fund.

It does not, however, seem from what has been given above, that an exact adaptation of the organisation of any existing society would best secure the end in view, which probably could only be attained by some arrangement that would best suit the present special position of the existing mining associations; for without cordial co-operation no successful scheme or federation could be hoped for; and no such co-operation could be expected unless all the present associations were fairly assured that their autonomy would be respected.

Again, it would not be to the interest of any body of men to start any association in London which would not be on a par at least with societies confined to some distinct branch of the engineering profession, for the central society should be on such a footing as to claim the respect and hearty co-operation of all the local societies. It should be located in

an appropriate building, if possible suitably situated for the use of the proposed Mining Institute of London, which would, of course, pay for the accommodation afforded. It should possess a spacious hall for meetings, and should have a good library.

The scheme should certainly not be adopted unless a clear income of £3,000 could be assured to it, which would probably be expended in the following way:—*

Publishing	£1,200
Rent	600
Coals, Wood, and Gas	20
Cleaning	30
Postages	250
Insurance and Library	100
Travelling	100
Meetings	150
Salaries	550
	£3,000

This central society should have its autonomy secured in the same way as would be that of the new Mining Institution of London, and the present provincial ones, and should have a charter, or at all events if only registered some acknowledged right to give diplomas or certificates of membership.

It is to the Imperial Mining Institute that the mineral owners of the various districts should be invited to subscribe, and to which the titled and influential should be pressed to attend.

With regard to the subscriptions, there seems to be no very great choice. The regulation rate for members, £3 3s., associates, £2 2s., and students, £1 1s., being the most suitable for the new Mining Institution of London; but every member, associate, or student paying respectively £2 2s., £1 1s., or 10s. 6d. to this, or to any of the recognised federated societies, should be allowed to become a member, associate, or student of the Imperial Mining Institute as well, on payment of an additional 21s., 15s., or 10s. 6d. each respectively. This should entitle them to all the rights of membership in the Imperial society. To make this more clear, any person would be entitled to become a member, associate, or student of the Imperial Mining Institute on payment of £3 3s., £2 2s., or £1 1s. respectively, but if he already belonged to any recognised federated society, his subscription to the Imperial Institute should be only £1 1s., 15s., or

* Estimate of expenses has been made chiefly by considering the balance sheet of the Institution of Mechanical Engineers.

10s. 6d.; an arrangement being entered into with the federated societies that no member, associate, or student of the Imperial Institute should pay more in the aggregate both for that and the local Institute to which he may belong, than £3 3s., £2 2s., and £1 1s., the federated society regulating its subscriptions accordingly to all of its members who are also members of the Imperial Institute, but it should be no bar to any member of a federated society becoming a member of the Imperial Institute should the subscription paid to the local society when added to that paid to the Imperial one, be lower than the £3 3s., £2 2s., and £1 1s., above mentioned.

All papers and discussions of the federated societies, should be sent up to London, and when passed by a committee, published in London and distributed to all the members of the Imperial as well as the federated Institutes. A recognised provincial society should be one which may reasonably be considered to be of such importance as to fairly represent the district in which it is situated, and which agrees to the arrangements above described.

All members of federated societies who are not also members of the central society should be only entitled to the Transactions contributed to the Imperial society by the Institution to which he belongs, and not be allowed to participate in any of the privileges of the Imperial Institute, such as attending its meetings, excursions, etc.

Each federated society should contribute towards the first expense of forming the central society, no premises being taken or expenses incurred until sufficient support has been promised.

The following may be considered as an indication as to how the necessary funds may be obtained :—

1.—It is hoped and expected that a considerable number of members might be attracted to the Mining Institute of London, such as, for instance, mineral proprietors, and a great many of those gentlemen whose professional avocations are in London and its immediate neighbourhood, or in the south of England. Possibly these members might at starting give an income of something like the following, supposing it turned out to be anything like a success :—

	£	s.	d.		£	s.	d.
50 Members paying	2	2	0	=	105	0	0
150 Associates at	1	1	0	=	157	10	0
50 Students at		10		=	26	5	0
					£288	15	0

Then a considerable number of the present members of local mining associations,—especially those whose standing in their professions would make it possible for them to obtain diplomas—would become members of the Imperial Mining Institute; these would be followed, probably, by other members and associates. For present purposes every existing member of the London institution has been considered as willing to join the Imperial one; and if all these and most of the members of existing societies join the Imperial Institute, the numbers would stand approximately as follows:—

	Members.	Associates.	Students.
Mining Institute of London	50	150	50
North of England Institute	450	120	50
Chesterfield and Midland	200	4	10
Midland	120	...	...
North Staffordshire	200	...	10
South Staffordshire	100	...	4
Mining Institute of Scotland	150	100	...
South Wales Institute of Engineers ...	220	10	10
Mining Institute of Cornwall... ...	180	10	...
	1,670	394	134

Or—

	£	s.	d.		£	s.	d.
1,670 Members at	1	1	0	=	1,753	10	0
394 Associates at		15	0	=	295	10	0
134 Students at		10	6	=	70	7	0
					£2,119	7	0

This, besides the contributions of members from mineral owners, foreign correspondents, and others connected with the commercial business of mining, who might desire to belong to the Imperial Institute alone.

2.—It is proposed to take the rest of the yearly sum necessary from the publishing expenses at present incurred by the various societies. These publishing expenses may be taken over a series of years to be about:—

	£	s.	d.
North of England Institute	670	0	0
Chesterfield and Midland Counties	220	0	0
Midland Institute	120	0	0
North Staffordshire Institute	100	0	0
South Staffordshire Institute	30	0	0
Scottish Institute	290	0	0
South Wales Institute	300	0	0
Cornwall Institute	60	0	0
	£1,790	0	0

and the half of which (£895) might reasonably be handed over to the central society as income.

These two amounts, therefore, secure the income required, without considering the contribution to the expense of publishing to be paid by the London society.

In addition to this, of course, there would be some preliminary expenses, which might be met by a call of 10 per cent. on the present amount of capital possessed by the various local associations, and which would amount to about £700. Should these figures be realised, a very handsome start might be made—a start well worthy of the *prestige* of the Mining Engineers of Great Britain.

This would provide for everything except a suitable hall for meetings, but this, in a place like London, can always be hired until the time came when suitable premises should be erected; for it should ever be borne in mind that the real object of such an institution will not be realised until it possesses all the accommodation which is necessary for its full development.

Should it be found possible to arrange an Imperial Mining Institute on any thing approaching the scale shadowed forth in this paper, it might be as well to consider the advisability of merging it with the Mining Association of Great Britain.

Many of the discussions, legal opinions, etc., on mining and other matters brought under the notice of this Association, would be well worth preserving in the Transactions of the Imperial Mining Institute, and the addition to its staff of a legal gentleman well informed on all Parliamentary work referring to mining would greatly add to its influence and power, and induce Indian and Colonial members to communicate papers on similar subjects from their own countries.

In fact if this amalgamation could be carried out a most brilliant career would be opened up, the Transactions, containing as they would all that was new and worth consideration in the Mining world, all the recent legal decisions in England, the various legal conditions under which mining is carried on in England, India, and the Colonies, would indeed be most valuable; and attracting as it would all those who are commercially connected with mining, as well as those who are professionally so employed, it would command a large influx of influential Subscribers and Associate members, far in advance of anything described above.

It would be time thrown away to discuss the views that the various local societies at present existing might have to such an arrangement. No outsider is capable of fully appreciating the very vast differences of

opinion that may exist in these various societies under such different conditions; it may, however, be reasonably anticipated that the smaller societies would receive a very great impetus from the arrangement, while the larger ones would to some extent suffer. Many who now hold back from the smaller societies would eagerly become members if they thought that they could also have membership in a large central association, whereas a great many of the members who, though living apart from, are members of the larger societies, would doubtless forsake them and either join the smaller ones that were nearer to them or altogether belong to the London Society. It does not, however, follow that the larger local societies would be materially injured thereby; their expenses, on the one hand, would be diminished, and probably the net balance in the future might be as large or larger than it is now, even after the central society has got to work. At all events, whatever income the local societies possess might be almost entirely spent upon their libraries and museums; the expenses of meetings, postage, miscellaneous printing, and other matters, being considerably diminished.

Thus, the quality of the transactions would be much improved and their amount would be materially increased; the two or three volumes published yearly would contain all that was worth recording in the mining world, and all these papers would be duly indexed and ready for speedy reference, instead of, as at present, being scattered here and there in the proceedings of the various societies now existing.

Again, it might also reasonably be expected that the foundation of a large and influential central society would draw together many who at present belong to no society whatever.

Any one, in glancing over Table 15 and seeing the proportion of members to tons extracted and sums realised, must be struck by the very great inequalities that exist. Leaving Cornwall out of the question, for obvious reasons, it will be seen that there is an average of about fourteen members for every million tons raised. If the several associations at present below this number could be raised up to it, the total number of members would be considerably increased; but it is possible and probable that this levelling up, as it were, would take place, without increasing the total number of members, by the process of members forsaking the larger institutions and joining the smaller ones, as before alluded to.

In order to bring this matter as much as possible under the notice of members, and to give every one an opportunity of judging for himself the absolute position of the question, an Appendix has been added giving the last balance sheet of every association alluded to in the paper, together with a table in which the principal items are tabulated for comparison.

Although the subject is not purely one connected with the profession of mining, it is submitted, nevertheless, that it comes within the range of papers suitable for the Transactions of the Institute and for the consideration of the mining profession generally; and that, after the paper has been read, it might be as well to publish it separately in a cheaper style than that in which the Transactions are published, and to distribute copies to the members of every local association, asking these associations to be kind enough to have the paper read and discussed before their members at some early period, sending up the several discussions to the writer to become incorporated in the Transactions of the North of England Institute.

APPENDIX.

TABLE No. 1.—TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

DR. AUGUST 1ST, 1885, TO JULY 20TH, 1886. CR.

	£	s.	d.
August 1st, 1885.			
To Balance at Bankers	651	0	4
1886.			
„ Interest on Investments	245	12	4
„ Rent of College Class-Rooms	48	14	2
„ Subscriptions for 1885-86, from 373 Original Members	783	6	0
„ „ „ 25 Ordinary „	77	14	0
„ „ „ 117 Associate „	245	14	0
„ Life Subscription, 1 Associate Member	20	0	0
„ Subscriptions for 1885-86, from 48 Students ...	50	8	0
„ „ „ 1 Associate ...	2	2	0
„ „ 1 New Ordinary Member	3	3	0
„ Life Subscription, 1 New Ordinary Member	25	0	0
„ Subscriptions for 1885-86, from 6 New Associate Members	12	12	0
„ Subscriptions for 1885-86, from 1 New Student ...	1	1	0
„ Subscribing Collieries	81	18	0
„ Members' Arrears	81	18	0
„ Students' „	6	6	0
„ Sale of Publications	29	10	3
	£2,365	19	1

Audited and found correct.

JOHN G. BENSON,
CHARTERED ACCOUNTANT.

Newcastle-on-Tyne,
27th July, 1886.

	£	s.	d.
August 1st, 1885.			
By Balance due Treasurer	19	8	1
1886.			
„ Publishing Account	297	2	6
„ Covers for Parts, Folding and Stitching	26	8	4
„ Binding and Sewing Volumes	22	11	10
„ Borings and Sections	42	18	6
„ Library Catalogue	119	19	8
„ Library	15	12	9
„ Stationery and Circulars	73	15	5
„ Postage	38	8	6
„ Books for Library, in addition to amount paid A. Reid	30	11	0
„ Printing and Stationery „ „ ...	1	3	3
„ Abstracts of Foreign Papers	39	13	9
„ Secretary's Incidental Expenses and Postage ...	52	14	4
„ Sundry Accounts and Payments	91	10	1
„ Travelling Expenses	2	15	10
„ Secretary's Salary	300	0	0
„ Cashier's Salary...	75	0	0
„ Clerks' Wages	140	14	6
„ Reporter's Salary	12	12	0
„ Furniture and Repairs	11	19	10
„ Rent	77	18	11
„ Rates and Taxes	16	12	8
„ Fire Insurance	8	14	11
„ Water, Gas, and Coals	13	4	6
„ Awards for Papers	29	15	6
„ Lit. and Phil. Society, Shelving, Wood Memorial Hall	35	0	0
„ Purchase of Stott's Records of Borings, &c. ...	20	0	0
„ Associated Conversazione Expenses	15	0	0
„ Wailes & Strang, Wood Memorial Hall Windows ...	12	10	0
„ Invested with Tyne Commissioners	500	0	0
„ Balance	222	2	5
	£2,365	19	1

TABLE No. 2.—NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

DR. THE TREASURER IN ACCOUNT WITH SUBSCRIPTIONS, 1885-86. CR.

		£ s. d.
To 457 Original Members, as per List 1885-6		959 14 0
„ 38 Ordinary Members „ „		117 12 0
„ 145 Associate Members „ „		324 10 0
„ 78 Students, as per List 1885-6, @ £1 1s.		81 18 0
„ Subscribing Collieries		81 18 0
„ 2 New Ordinary Members, @ £3 3s.		28 3 0
„ 8 New Associate Members, @ £2 2s.		16 16 0
„ 1 New Student, @ £1 1s.		1 1 0
		1,611 12 0
„ Arrears as per Balance Sheet, 1884-85	£543 18 0	
Deduct—Irrecoverable	222 12 0	
		321 6 0
		£1,932 18 0

	PAID. £ s. d.	UNPAID. £ s. d.
By 373 Original Members paid	783 6 0	.....
„ 84 „ „ unpaid	.....	176 8 0
„ 25 Ordinary Members paid	77 14 0	.....
„ 13 „ „ unpaid	.....	39 18 0
„ 118 Associate Members paid	267 16 0	.....
„ 28 „ „ unpaid	.....	58 16 0
„ 49 Students paid	50 8 0	.....
„ 28 „ unpaid	.....	29 8 0
„ Subscribing Collieries paid	81 18 0	.....
„ 2 New Ordinary Members paid	28 3 0	.....
„ 6 New Associate Members paid	12 12 0	.....
„ 2 „ „ unpaid ...	.....	4 4 0
„ 1 New Student paid	1 1 0	.....
	1,302 18 0	308 14 0
„ Members' Arrears	81 18 0	201 12 0
„ Students' „	6 6 0	31 10 0
	1,391 2 0	541 16 0
		1,391 2 0
		£1,932 18 0

TABLE No. 3.—CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

ABSTRACT OF ACCOUNTS, YEAR ENDING MARCH 25, 1886.

INCOME.	£	s.	d.
177 Members and Hon. Members	278	15	6
One paid after resignation	1	11	6
10 Students	10	10	0
1 „ as Member and Entrance	2	2	0
5 New Members—Subscription and Entrance	13	2	6
2 New Students, and Entrance	3	3	0
1 New Associate Member	1	0	0
196			
Three Members in advance, 1886-7	1	14	6
One Member in advance, 1887-8	1	11	6
Two New Members, and Entrance	5	5	0
Three New Associates	3	0	0
One New Student	1	0	0
Arrear Subscriptions received, 1882-3	3	3	0
„ „ 1883-4	7	17	6
„ „ 1884-5	30	19	6
Transactions and Excerpts Sold	23	19	4
Midland Railway Debenture Interest	15	10	0
Bank Interest	1	17	4
Letting of Council Room	1	10	0
Balance	49	6	7
Unpaid Arrears to Collect	146	9	6
	£606	8	3

EXPENDITURE.	£	s.	d.
Printing Transactions	209	8	8
Bemrose & Son, for Printing and Stationery	14	0	0
Sundry Printing and Stationery	8	4	11
Leicester Excursion—Printing, Dinner, &c.	14	7	11
Annual Meeting at Derby	2	10	0
Auditors	3	3	0
Reporting Proceedings	14	1	6
Stephenson Memorial Hall—Occupation	11	6	6
Postages, Parcels, Telegrams	29	17	0
Travelling and Incidentals	5	9	2
Requisites and Services	3	10	11
Solicitors' Account—Shipton & Co.	3	7	0
Secretary's Salary, Assistance, and Use of Office	140	0	0
Banker's Charges		12	2
Arrear Subscriptions	146	9	6
	£606	8	3

TABLE No. 4.—MIDLAND INSTITUTE.

DR. THE TREASURER IN ACCOUNT WITH THE MIDLAND INSTITUTE. CR.

1886.	£	s.	d.	1885.	£	s.	d.
June 30.—To Subscriptions Received	131	5	0	July 1.—By Balance due to Treasurer	29	1	7
„ Sale of Transactions	3	12	6	1886.			
„ „ Dinner Tickets	9	12	6	June 30.—By R. E. Griffiths	45	0	0
„ Amount received from Bank	87	19	1	„ Jas. Fox & Son (Annual Dinner) ...	11	11	0
„ Bank Interest		5	7	„ Reporter	9	0	0
„ Balance due to Treasurer...	10	5	1	„ Room Cleaning	2	18	3
				„ Insurance		15	9
				„ Barnsley Gas Co.		8	6
				„ Hire of Rooms for Meetings in Leeds and Sheffield	1	6	0
				„ T. L. Stephenson & Son		18	4
				„ Secretary's Salary...	25	0	0
				„ „ Expenses	2	17	6
				„ Rent of Room	15	0	0
				„ Stamps, Telegrams, Post Cards, and Sundries	11	9	3
				„ Banking Company	87	13	7
	£242	19	9		£242	19	9

GENERAL STATEMENT.

1886. LIABILITIES.	£	s.	d.	1886. ASSETS.	£	s.	d.
June 30.—To R. E. Griffiths	81	16	6	June 30.—By Cash in Bank	15	8	10
„ Reporter	7	10	0	„ Arrears of Subscriptions	47	5	0
„ Gas Company		1	4	„ Value of Transactions—5,788, at 1s. per copy	289	8	0
„ Balance due to Treasurer...	10	5	1				
„ Balance, being Capital	252	8	11				
	£352	1	10		£352	1	10

TABLE No. 5.—THE TREASURER IN ACCOUNT WITH THE NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS,

FOR THE YEAR ENDING JANUARY, 1883.

DR.	£	s.	d.	CR.	£	s.	d.
To Bank Balance	77	0	6	By Printing, Lithography, and Stationery	75	7	6
„ Building Society (Deposit)	300	0	0	„ Rent of Rooms	9	10	6
„ Cash in hands of Secretary		3	8	„ Reporter's Salary	22	16	0
„ Subscriptions and Arrears of Subscriptions, &c. ...	142	16	0	„ Expenses, two years	8	10	8
„ Interest on Deposit at 4½ per cent.	13	10	0	„ Secretary's Salary	40	0	0
„ Sale of Transactions	5	10	0	„ Balance	83	6	7
„ Bank Interest		11	1	„ Building Society	300	0	0
	£539	11	3		£539	11	3

TABLE No. 6.—SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

DR. TREASURER'S ACCOUNT FOR THE YEAR ENDING DECEMBER 31ST, 1886. CR.

	£	s.	d.
Bank Balance	299	18	10
Subscriptions Received	133	17	6
Bank Interest	7	8	4
	£441	4	8

	£	s.	d.
Secretary and Reporter's Salaries	50	0	0
Mechanics' Institute, Rent of Mining and Geological Museums	37	0	0
Dudley Herald for Printing Transactions and Circulars	19	18	3
S. Mills for Printing Transactions for 1881	10	0	0
G. H. Parke, Dinners, &c., to Visitors and Reporters at Annual Dinner	3	12	0
Fee to Waiters and Wine for Visitors at Annual Dinner	1	3	0
Grand Hotel, Half of Dinner Account for Visitors, &c., at Chesterfield Institute Excursion	2	2	0
Cresse & Co., Account for Lithography, &c.	3	11	0
C. Bourne for Teas at Meetings	2	4	8
Post Cards, Wrappers, and Stamps for year	9	13	8
Fee to Workman and Expenses of Bradeley Excursion		10	0
Dinguan & Co. for opinion on Rules		13	4
Bank Charges		7	6
Balance in Bank	300	9	3
	£441	4	8

BALANCE SHEET, 1886.

LIABILITIES.	£	s.	d.
Nil.			
Balance	343	0	9
	£343	0	9

ASSETS.	£	s.	d.
By Cash at Bankers	300	9	3
„ Subscriptions due December 31st, 1886	42	11	6
	£343	0	9

This is exclusive of considerably more than £100 worth of property in the Mining Museum, for which *no credit is taken*.

Examined and found correct, March 2nd, 1887.

(Signed) WM. JNO. HAYWARD.
DANIEL ROGERS.

TABLE No. 7.—MINING INSTITUTE OF SCOTLAND.

ABSTRACT OF ACCOUNTS FOR SESSION 1885-6.

DR.

	£	s.	d.
To Balance from 1885–6	193	5	11½
„ 174 Members' Subscriptions at 21s.	182	14	0
„ 242 do. do. 10s. 6d.	127	1	0
„ 1 do. do. 20s. 6d.	1	0	6
„ 2 do. do. in advance at 21s. ...	2	2	0
„ 2 do. do. do. 10s. 6d....	1	1	0
„ 6 do. do. in arrears at 21s. ...	6	6	0
„ 7 do. do. do. 10s. 6d. ...	3	13	6
„ Received for Transactions, &c.	18	18	8
„ Do. Rents for Hall	22	15	6
„ Do. Advertisements	7	7	0
„ Mining Exhibition Surplus	27	14	9
„ Interest on Bank Account	4	2	11
	£598	2	9½

CR.

	£	s.	d.
By Printing and Stationery	285	0	7
„ Books, Maps, and Bookbinding	44	8	8½
„ Rents of Halls	16	19	3
„ Gas and Assessments	4	16	4½
„ Stamps, Carriages, &c....	5	5	2½
„ Bookcase, &c.	6	12	1½
„ Sundry Payments	4	2	5
„ Cleaning Hall	6	0	0
„ Salaries	69	14	0
„ Balance	155	4	1½
	£598	2	9½

TABLE No. 8.—THE SOUTH WALES INSTITUTE OF ENGINEERS.

FINANCIAL STATEMENT, SESSION 1885-86.

DR. CR.

RECEIPTS UP TO 29TH OCT., 1886.	£ s. d.	£ s. d.
To Balance, 29th October, 1885		167 10 5
„ Cash received from Members	745 19 0	
„ Dividends, Midland Railway	35 11 7	
„ Sale of Books	13 10 8	
„ Interest from Bank	4 0 5	
		799 1 8
Total		£966 12 1

EXPENDITURE UP TO 29TH OCT., 1886.	£ s. d.	£ s. d.
By Printing and Stationery...	95 3 8	
„ Engraving	62 0 0	
„ Reporting	31 10 0	
„ Secretary	80 0 0	
„ Sundry Expenses	91 18 9	
„ Institute Rooms—		
Rent and Hire of Rooms	34 11 8	
Insurance and Taxes...	1 19 1	
Gas and Water	1 7 6	
Caretaker	13 0 0	
Furnishing	143 1 8	
„ Library—Newspapers ... £1 9 2		
Binding ... 13 0 0		
	14 9 2	
„ Excursion	78 6 4	
„ Midland Railway, 4 per cent. Stock ...	12 0 0	
		659 7 10
„ Balance		307 4 3
Total		£966 12 1

GENERAL STATEMENT.

ASSETS UP TO 29TH OCT., 1886.	£ s. d.	£ s. d.
To Balance brought down		307 4 3
„ £607, Ordinary Midland Stock... ...	734 13 2	
„ £205 5s., 4 per cent. Perpetual Preference Stock	205 5 0	
		939 18 2
„ Subscriptions:—		
Arrears to 29th October, 1886 ...	396 18 0	
Less—Irrecoverable	23 2 0	
		373 16 0
„ Furniture, &c.		250 0 0
Total		£1,870 18 5

LIABILITIES UP TO 29TH OCT., 1886.	£ s. d.	£ s. d.
By Printing, &c.	97 10 7	
„ Engraving	18 3 0	
„ Institute Rooms—		
Bal. of Furnishing Account £158 19 0		
Gas and Water 1 0 6		
	159 19 6	
„ Excursion, balance	46 5 0	
„ Sundries	5 0 0	
		326 18 1
„ Balance		1,544 0 4
Total		£1,870 18 5

TABLE No. 9.—MINING ASSOCIATION AND INSTITUTE OF CORNWALL.

FINANCIAL STATEMENT, 1ST JANUARY, 1886, TO 31ST DECEMBER, 1886.

RECEIPTS.	£	s.	d.
Balance at Bank and in hand, 1st January, 1886 ...	82	11	11
Subscriptions from Members and Associates	273	14	0
„ „ Mines	22	1	0
Sale of Proceedings, &c.		19	6
Donations towards Prizes	5	5	0
„ „ Room at Camborne	3	1	0
Affiliation Fees	4	15	0
	£392	7	5

EXPENDITURE.	£	s.	d.
Printing and Stationery (including Transactions) ...	30	14	4½
Salaries and Arrears	140	0	0
Excursions and Meetings	13	6	7
Postages	10	18	11
Prizes	34	2	7
Sundries	2	4	6½
	231	7	0
Balance at Bank and in hand, 31st December, 1886 ...	161	0	5
	£392	7	5

BALANCE SHEET, 31ST DECEMBER, 1886.

ASSETS.	£	s.	d.
Members' Subscriptions in arrear...	66	17	6
Subscriptions from Mines „	1	1	0
Donation promised	1	1	0
Cash with Treasurer and Secretary, as above	161	0	5
	£229	19	11

LIABILITIES—*Nil.*	£	s.	d.
Balance of Assets over Liabilities	£229	19	11

TABLE No. 10.—THE BRITISH SOCIETY OF MINING STUDENTS.

ABSTRACT OF ACCOUNTS, ENDING JUNE 30TH, 1885.

INCOME.	£ s. d.	£ s. d.
To Subscriptions in advance as per last Balance Sheet		36 3 0
SUBSCRIPTIONS—		
To Honorary Members as per in Account with Subscriptions	28 13 0	
Less paid in advance as per Balance Sheet, June 30th, 1884	13 13 0	
		15 0 0
Senior Members as per in Account with Subscriptions	19 0 0	
Less paid in advance as per Balance Sheet, June 30th, 1884	8 0 0	
		11 0 0
Members as per in Account with Subscriptions	39 2 6	
Less paid in advance as per Balance Sheet	14 10 0	
		24 12 6
Total advance as above	36 3 0	
		86 15 6
Extra Receipts, Journals, &c.	2 19 0	
Arrears Collected	1 17 6	
		4 16 6
Net Receipts for year		91 12 0
ARREARS ACCOUNT—		
As per last Balance Sheet	10 2 6	
Collected as above	1 17 6	
Balance	8 5 0	
Arrears June 30th, 1885	23 12 6	
	31 17 6	
Irrecoverable	8 5 0	
		23 12 6
Advanced by Treasurer		20 17 5
		£136 1 11

EXPENDITURE.	£ s. d.	£ s. d.
By Newspapers to Members and Application Forms for Subscriptions	19 6	
P.O. Orders	1 6	
Postage, &c.	6 10 8	
Widdison, Printing Vol. VIII., Nos. 1, 2, 3, 4, 5, and 6	69 11 0	
Pawson & Brailsford for Stationery	12 0	
Carriage of Parcels	0 6	
Secretary and Treasurer for Expenses, &c.	20 0 0	
		97 15 2
Balance due Treasurer last year		14 14 3
		112 9 5
Expenditure for year		
Arrears of Subscriptions		23 12 6
		£136 1 11

TABLE No. 11.—THE BRITISH SOCIETY OF MINING STUDENTS.

THE TREASURER IN ACCOUNT WITH SUBSCRIPTIONS, 1884-5.

	£ s. d.	£ s. d.
2 Free Honorary Members		.....
66 Honorary Members at 10s.		33 0 0
41 Senior Members at 10s.		20 10 0
139 Members at 7s. 6d.	52 2 6	
2 New Members at 10s.	1 0 0	
17 Entrance Fees at 2s. 6d.	2 2 6	
		55 5 0
		108 15 0
1 Advance, Honorary		2 3 0
		£110 18 0

	£ s. d.	£ s. d.
2 Free Honorary Members		.....
48 Honorary Members at 10s.	24 0 0	
5 „ „ paid and resigned at 10s.	2 10 0	
1 „ „ paid in advance ...	2 3 0	
		28 13 0
13 „ „ Arrears at 10s. £6 10 0		
61		
38 Senior Members at 10s.		19 0 0
3 „ „ arrears at 10s. ... 1 10 0		
41		
87 Members at 7s. 6d....	32 12 6	
13 „ paid and resigned at 7/6 each	4 17 6	
17 „ entrance fees at 2/6 each	2 2 6	
		39 12 6
39 „ arrears at 7s. 6d. each ..14 12 6		
2 „ „ at 10s. each (New Members) 1 0 0		
128	15 12 6	87 5 6
Total arrears 23 12 6		23 12 6
232 Total.		
		£110 18 0

TABLE No. 12.—THE INSTITUTION OF CIVIL ENGINEERS.

DR. ABSTRACT OF RECEIPTS AND EXPENDITURE FROM APRIL 1ST, 1885, TO MARCH 31ST, 1886. CR.

	£	s.	d.
To Balance	3,235	18	9
„ Subscriptions:—			
Arrears	375	18	0
Current	12,690	0	6
Advance	129	19	6
„ Library Fund	205	4	6
„ Minutes of Proceedings—Repayment for Binding, &c.	231	8	2
„ Publication Fund	3	3	0
„ Dividends and Interest on £57,000 invested ...	2,055	14	10
CAPITAL.			
„ Admission Fees	3,446	2	0
„ Life Compositions	367	10	0
„ Interest on £14,642 13s. 10d., Trust Funds Invested	440	15	3
	£23,181	14	6

SUMMARY OF INVESTMENTS.			
Institution Investments	57,000	0	0
Trust Funds:—			
Telford Fund	8,716	4	9
Manby Donation	250	0	0
Miller Fund	5,124	14	7
Howard Bequest	551	14	6
	£71,642	13	10

	£	s.	d.
By House and Establishment Charges	1,851	11	1
„ Postages, Telegrams, and Parcels	216	12	3
„ Stationery and Printing	600	2	1
„ Watt Medal	2	7	6
„ George Stephenson Medal	2	7	6
„ Diplomas	55	10	1
„ Annual Dinner (Official Invitations, &c.)	277	19	2
„ Salaries and Wages	2,681	18	4
„ Library	528	6	4
„ Publications—4 Vols. a year	9,178	4	11
„ Legal Expenses	92	0	10
CAPITAL INVESTMENTS.			
„ £3,000, Metropolitan Board of Works 3½ % Stock	3,281	5	0
TRUST FUNDS.			
„ Telford Premiums	196	14	1
„ „ Medals	6	0	0
„ Miller Scholarship	40	0	0
„ „ Prizes	102	17	11
„ Balance, March 31st, 1886	4,067	17	5
	£23,181	14	6

TABLE No. 13.—INSTITUTE OF MECHANICAL ENGINEERS.

CR. ACCOUNT OF EXPENDITURE AND RECEIPTS FOR YEAR ENDING 31ST DECEMBER, 1886. DR.

EXPENDITURE.	£	s.	d.	RECEIPTS.	£	s.	d.
To Printing and Engraving Proceedings, 1886	665	5	10	By ENTRANCE FEES:—			
„ Reprinting former Proceedings	126	14	0	75 New Members at £2	150	0	0
„ Stationery, Binding and General Printing	228	12	4	7 „ Associates at £2	14	0	0
„ Rent	550	0	0	20 „ Graduates at £1	20	0	0
„ Salaries and Wages	1,377	19	0	5 Graduates transferred to Members at £1 ...	5	0	0
„ Coals, Firewood, and Gas	28	2	6	„ SUBSCRIPTIONS FOR 1886:—			
„ Fittings and Repairs	51	19	10	1,345 Members at £3	4,035	0	0
„ Postages	248	13	10	33 Associates at £3	99	0	0
„ Insurance	5	2	3	110 Graduates at £2	220	0	0
„ Petty Expenses...	48	18	9	5 Graduates transferred to Members at £1 ...	5	0	0
„ MEETING EXPENSES:—Printing	318	1	3	„ Subscriptions in arrear	198	0	0
Translations, &c.	72	19	0	„ Subscriptions in advance	71	0	0
Reporting	46	18	2	„ Donation to Library	324	0	0
Diagrams, Screen, &c.	78	19	7	„ Interest from Investments	499	18	11
Travelling and Incidentals...	101	12	5	„ Extra Copies Proceedings sold	60	17	0
„ Dinner	166	11	6				
„ Research...	221	18	7				
„ Books Purchased	14	3	7				
	4,352	12	5				
Accounts owing, not yet rendered, say	300	0	0				
Balance, being excess of Receipts over Expenditure carried down	1,049	3	6				
	£5,701	15	11		£5,701	15	11

DR. BALANCE SHEET AS AT 31ST DECEMBER, 1886. CR.

	£	s.	d.		£	s.	d.
To SUNDRY CREDITORS:—				By Cash in Bank	1,679	16	9
Accounts owing, not yet rendered, say	300	0	0	„ Investments	13,467	1	6
				„ Subscriptions in arrear	423	0	0
Capital of the Institution at this date	18,574	18	3	„ Office Furniture and Fittings	315	0	0
				„ Library and Proceedings	2,670	0	0
				„ Drawings, Engravings, Models, Specimens, and Sculpture	320	0	0
	£18,874	18	3		£18,874	18	3

TABLE No. 14.—SOCIETY OF CHEMICAL INDUSTRY.

TREASURER'S STATEMENT FOR THE YEAR 1885.

DR.				CR.			
		£	s.	d.		£	s.	d.
To Cash at Bank (less amount owing to Secretary, 31st December, 1884)		774	18	6	By Publishing	1,312	6	8
„ ANNUAL SUBSCRIPTIONS:—					„ Editorial	608	13	7
4 for the Year 1883	4	4	0		„ Printing Sundries	83	5	3
23 „ 1884	24	3	0		„ SECTIONAL EXPENSES:—			
1,941 „ 1885	2,038	1	0		Birmingham Section	8	0	3
36 „ 1886	37	16	0		Bristol „	2	17	2
2,004					Glasgow „	44	18	6
					Liverpool „	27	14	11
Excess Payments		3	3		London „	47	15	3
„ Life Composition Fees	105	0	0		Manchester „	36	8	0
„ Interest on Deposit Account	20	12	9		Newcastle „	25	11	2
„ Amount received from Council of the International Inventions Exhibition	134	17	5		Nottingham „	26	0	1
„ JOURNAL:—					„ Secretary's Salary	200	0	0
Advertisements 106 4 2					„ Honorarium voted to Ed. Hughes for services rendered to Hon. Treasurer in 1884	21	0	0
Sales 242 11 3					„ OFFICE EXPENSES:—			
	348	15	5		Rent	61	8	9
					Fire, Cleaning, Attendance, &c.	12	18	3
					Gas		8	5
					„ Stationery	38	8	4
					„ Amount paid on account of expenses in connection with the Inventions Exhibition	120	1	8
					„ Auditors' Fees, Sundries	44	17	2
					„ Treasurer's Petty Cash	13	3	9
					„ Balance in hand (31st December, 1885)	752	14	2
	£3,488	11	4			£3,488	11	4

TABLE No. 15.—STATISTICS OF THE VARIOUS SOCIETIES WITH REFERENCE TO THEIR POSITION WITH REGARD TO THE DISTRICTS THEY REPRESENT.

NAME OF INSTITUTE.	PRESIDENT.	YEAR.	MEMBERS.							SUBSCRIPTIONS.																
			Hon.	Life.	Ordinary.		Associates	Students	Total.	Ordinary.			Associates.		Students.		Amount of Paid Subscriptions.	Amount of Arrears.	Percentage of Arrears to Paid Subscriptions.	Capital.	Income from Capital.	Total Income.	Tons of Mineral raised in District.	No. of Members to every 1,000,000 Tons raised.	Income from Members to every 1,000,000 Tns. raised	Total Income to every 1,000,000 Tons raised.
					Class 1.	Class 2.				Class 1.		Class 2.														
										£	s.	d.	£	s.	d.	£	s.	d.	£	£	£	£	Million Tons.		£	£
North of England Inst. of Mining and Mechanical Engineers ...	Sir L. Bell, Bart.	1886-87	20	21	439	41	156	69	705	3	3	0	2	2	0	2	2	0	1	1	0	1,391	542	39	4,902	294	1,714	44	16·	31·6	39·
Chesterfield and Midland Inst....	Lord Edward Cavendish	1885-86	14	8	219	9	4	10	242	1	11	6	1	1	0	1	0	0	1	0	0	368	146	39	430	17	410	60½	6·3	8·2	9·1
Midland Inst. ...	A. M. Chambers	1886-87	16	4	143	...	...	...	143	1	1	0	...			...			...			131	47	36	252	...	144				
No. Staffordshire	.. ...	1883	15	...	226	...	...	21	247	1	1	0	...			...			10	6		143	43	30	300	13	162	18¾	24·	14·7	16·1
So. Staffordshire	... ...	...	...	...	193	...	...	13	206	...			...			...			...			134	43	32	300	...	141				
Mining Inst. of Scotland ...	Jas. S. Dixon ...	1887-88	2	...	204	253	...	...	457	1	1	0	0	10	6	...			...			324	...	...	155	4	405	24½	18·6	13·2	16·5
So. Wales Inst. of Engineers ...	Archibald Hood	1886-87	...	7	282	...	27	26	342	2	2	0	...			...			1	1	0	746	397	53	940	40	799	31	11·	24·	25·8
Mining Inst. of Cornwall ...	G. L. Bassett ...	1886	4	6	216	8	18	...	242	10	6		...			...			...			296	67	22	161	...	310	½	484·	592·	620·
			71	46	1,922	311	205	139	2,584													3,533	1,285	36	7,440	368	4,085	179¼			

N.B.—Since the paper was printed it has been pointed out that the second and third of the above-named institutes do not cover or include Manchester and Liverpool Inspection Districts, and consequently the figures in the four last columns against those institutes should be altered to 36½, 10·5, 13·7, and 15·2. For the 24 million tons raised in the said Inspection Districts there appears to be no distinctly mining institute, although the Manchester Geological Society takes cognizance occasionally of mining matters.

TABLE No. 16.

SHOWING THE NUMBER OF MEMBERS THAT ARE IN MORE THAN ONE ASSOCIATION.

CLASS OF MEMBERS. ☞	North of England Institute of Mining and Mechanical Engineers.					South Wales Institute of Engineers.					Midland Institute of Mining, Civil, and Mechanical Engineers.					Chesterfield and Midland Co.'s Institute of Engineers.					Mining Institute of Scotland.					Mining Institute of Cornwall.					South Staffordshire and East Worcestershire Institute of Mining Engineers.				
	Original.	Ordinary.	Associates.	Students.	Total.	Original.	Ordinary.	Associates.	Students.	Total.	Original.	Ordinary.	Associates.	Students.	Total.	Original.	Ordinary	Associates.	Students.	Total.	Original.	Ordinary.	Associates.	Students.	Total.	Original.	Ordinary.	Associates.	Students.	Total.	Original.	Ordinary.	Associates.	Students.	Total.
North of England Institute of Mining and Mechanical Engineers	...	...	...	...	...	...	27	...	1	28	...	39	...	...	39	...	36	...	...	36	10	2	...	...	12	...	3	...	...	3	...	...	...	...	...
South Wales Institute of Engineers	24	1	2	1	28	...	...	...	...	...	...	5	...	...	5	...	7	...	...	7	2	1	...	...	3	...	1	...	...	1	...	...	...	...	...
Midland Institute of Mining, Civil, and Mechanical Engineers	31	3	5	...	39	...	5	...	...	5	...	...	...	...	...	...	16	...	...	16	...	...	...	...	...	...	1	...	...	...	...	...	...	...
Chesterfield and Midland Co.'s Institute	26	3	7	...	36	...	7	...	...	7	...	16	...	...	16	...	...	...	...	...	2	...	...	...	2	...	1	...	...	1	...	...	...	...	...
Mining Institute of Scotland...	6	2	4	...	12	...	3	...	...	3	...	...	...	...	...	...	2	...	...	2	...	...	...	...	...	...	1	...	...	1	...	...	...	...	...
Mining Institute of Cornwall...	1	1	1	...	3	...	1	...	...	1	...	1	...	...	1	...	1	...	...	1	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...
South Staffordshire and East Worcestershire Institute of Engineers	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	88	10	19	1	118	...	16	...	...	16	...	17	...	...	17	...	3	...	...	3	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...

TABLE No. 17.

GENERAL SUMMARY OF THE WHOLE MINERAL PRODUCE OF GREAT BRITAIN,* ARRANGED ACCORDING TO THE DISTRICTS ALLUDED TO IN THE PAPER.

	COAL.	CLAY.	IRON.	LEAD.	OTHER MINERALS.	TOTALS.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
North of England	36,579,823	494,843	6,638,663	20,627	170,766	43,904,722
Chesterfield and Midland ...	56,723,716	401,794	2,808,151	1,666	537,057	60,472,384
Staffordshire	14,767,398	229,424	1,755,945	2,529	1,956,217	18,711,513
Scotland	20,373,478	429,736	1,509,995	4,316	2,082,633	24,400,158
South Wales	28,968,504	371,831	1,359,680	7,585	701,862	31,409,462
Cornwall	.....	493,860	1,928	1,565	59,388	556,741
	157,412,919	2,421,488	14,074,362	38,288	5,507,923	179,454,980

The writer has been at a loss to make this division so as to correspond with what might fairly be supposed to be the legitimate area under the influence of the various institutions described.

* NOTE.—The produce of mines classed under Coal Mines Regulation Act, 1872, is taken from the Summary for 1886, published early in 1887, and the produce of the metalliferous mines from the Mineral Statistics of the United Kingdom for 1885.

(The President having to leave the meeting in order to go away from Newcastle by train, the chair was taken by Mr. John Marley.)

The CHAIRMAN said the meeting would be glad to hear, as a sort of preliminary discussion, any remarks which any gentleman had to make upon Mr. Bunning's paper.

Mr. W. F. HOWARD, Secretary of the Chesterfield and Midland Counties Institution of Engineers, said he had received a copy of the paper in advance, and had marked some corrections; but there was one thing which he had not corrected, as he did not notice it at the time. It appeared in the paper that the Chesterfield and Midland Counties Institution and the Midland Institute were credited with a district which raised 60½ million tons of mineral. These two societies—although they, of course, had members in other districts—did not pretend, and never pretended, to represent more than the Midland coal-field; but Mr. Bunning had evidently put the Manchester and Liverpool inspection districts—that was, the Lancashire coal-field and North Wales—in the figures against the two societies, which made them seem to occupy a very peculiar position. Instead of the produce of the district of the two Midland societies being 60½ millions, the produce was only 36½ million tons, and this raised the number of members per million tons in the Midland district from 6·3, at which Mr. Bunning placed it, to 10·5, the subscriptions income from 8·2 to 13·7, and the total income from 9·1 to 15·2. He would like these corrections made before the paper was published in the Transactions. He thought the Manchester and Liverpool districts should not be passed over altogether. His impression was that they belonged to the North of England. He did not wish to say anything disparaging of the North of England Institute. He had been a member of it for twenty-six years, and greatly valued it; but an alteration in the figures, charging the 24 million tons produced by the two Lancashire districts to the North of England, instead of to the two Midland Institutes, would reduce the apparent work shown in the paper by the North of England, which was rather to the disparagement of other societies. He thought the name of the proposed central institute should be something more modest than that suggested by Mr. Bunning. There was an Institution of Civil Engineers, an Institution of Mechanical Engineers, and if the proposed new institute was called the Institution of Mining Engineers it would be enough. He had heard Mr. Bunning's paper very favourably spoken of by gentlemen belonging to the Midland and other societies. If the paper was referred to the other societies, it would be discussed and favourably considered; and he had no doubt they

would all do their best to get the proposal into something like practical shape and form, which would be acceptable to all.

Mr. MILLS (Midland Institute) said the proposal brought forward by Mr. Bunning had been under consideration for some years by many of them, and they must thank Mr. Bunning for putting the matter into some sort of form. It was hardly to be expected that they would agree with everything Mr. Bunning proposed, but he felt sure that, speaking for the Council of the Chesterfield Association, such a federation was not only desirable, but really necessary. They had heard an excellent Address that day, and it was a sad thing that Sir Lowthian Bell's Address would be sent out only to members of the North of England Institute, and not to all the engineers in England. To get Mr. Bunning's proposals into practical form, it would be well if the council of each of the different associations were asked to send representatives to a meeting in London to discuss the matter, and to put it into some form to lay before their own institutions. If such a meeting could be arranged it would put the matter right. As to the name of the new institution, that was a point which could be settled afterwards. He hoped this would not be allowed to drop, but would be taken up by all the different institutions.

Mr. W. J. BIRD said that, as a member of the North of England Institute, he would take the opportunity of recording his appreciation of Mr. Bunning's paper, not because the North of England Institute had had the honour of Mr. Bunning's assistance as secretary for many years, but for the reason that the proposals it contained were highly necessary, and would be very advantageous if carried out. One of the previous speakers had deprecated the proposed title of "Imperial." He thought Mr. Bunning would have no objection to enlarge the society and take in the mining institutes of the Colonies and India. A mining institute had been started in New South Wales. He thought Mr. Bunning would be able to enlarge the scope of the society, and include the societies in the Colonies and India; and this would be a justification for the introduction of the word "Imperial" into the title of the society.

The CHAIRMAN asked Mr. Howard to address a letter to Mr. Bunning stating the alterations he wished made, so that the paper might be corrected before going out.

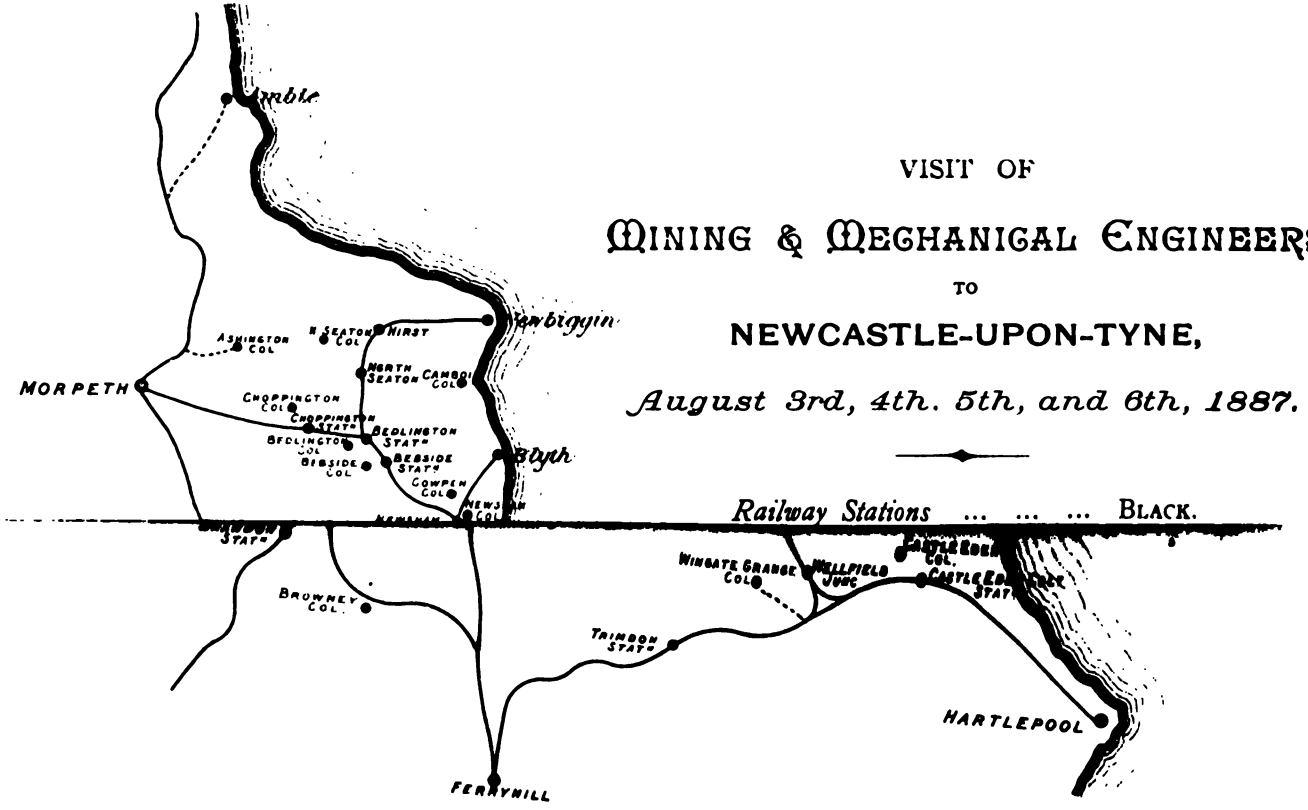
Mr. HOWARD said he would be glad to do that.

The CHAIRMAN said, the last paragraph of Mr. Bunning's paper suggested that it would be well to distribute copies of the paper among the members of all the various mining associations; and this would be carried out. The paper would, of course, be referred to a committee of the North

of England Institute, with powers to communicate and consult with the councils of other mining associations to further consider the details, and he moved that this be done.

Mr. W. G. LAWS seconded the resolution, which was agreed to.

The SECRETARY having announced the result of the voting for the election of officers the meeting separated.



VISIT OF

MINING & MECHANICAL ENGINEERS

TO

NEWCASTLE-UPON-TYNE,

August 3rd, 4th. 5th, and 6th, 1887.

PROGRAMME OF THE EXCURSIONS

MADE DURING THE

VISIT OF THE MINING ENGINEERS TO NEWCASTLE.

THURSDAY, AUGUST 4TH.

INSPECTION OF COLLIERIES.

The following notes will afford some idea to members who could not attend the meeting as to the principal objects of interest which were seen at the undermentioned collieries, opened to their inspection by the kindness of their respective owners.

A.—Collieries situated on the Blyth and Tyne Railway.

CRAMLINGTON COLLIERIES.

SEATON DELAVAL, NEW DELAVAL, AND NEW HARTLEY COLLIERIES.

SEATON DELAVAL.

WINDING ENGINE.—High Pressure Vertical Condensing Engine; cylinder, 39 inches, 6 feet stroke; drum, 18 feet 10 inches diameter; single deck cage, carrying two tubs, 6½ cwt. of coals each; two winding shafts, each 8 feet diameter, originally sunk for "corves."

HAULING ENGINE, UNDERGROUND.—High Pressure Horizontal Non-condensing; two cylinders, each 18 inches diameter, 3 feet stroke; geared 2½ to 1, working endless chain; steam brought from surface.

PUMPING ENGINE.—Vertical Condensing Beam Engine; one cylinder, 72 inches diameter, 7 feet stroke. Pumps.—Bottom set lifting, 16 inches diameter, 6 feet stroke; middle set forcing, 16 inches diameter, 6 feet stroke; top set, 18 inches diameter, 6 feet stroke.

SCREENS.—Ordinary, with "Yankee Jack" system.

VENTILATION.—Two furnaces.

WORKINGS.—Longwall system.

COAL-WASHING MACHINE.—Sheppard's, to wash 200 tons in 11 hours.

FITTING SHOPS.—Gas works, saw mill, and steam prop-cutter.

NEW DELAVAL.

Forster Pit.

Winding Engine.—High Pressure Horizontal Engine; 2 cylinders, 36 inches diameter, 6 feet stroke each; drum, 18 feet 6 inches diameter; double deck cage, carrying 4 tubs, 8½ cwt. of coals each.

Hauling Engines, Underground.—Air Compressor; 2 cylinders, 20 inches diameter, 3 feet 6 inches stroke each; 1 air cylinder, 22 inches diameter, 3 feet 6 inches stroke; air receiver and pipes. Hauling engine in-bye; 1 cylinder, 12 inches diameter, 24 inches stroke; geared 4 to 1; working endless chain.

Self-acting Endless Rope.—On inclined plane.

Pumping Engine, Underground.—Compound Horizontal Engine; high pressure cylinders, 35 inches diameter; low pressure cylinders, 60 inches diameter; stroke, 4 feet; two double-acting plungers, each 9 inches diameter and 4 feet stroke; steam brought from surface.

Screens.—"Billy Fairplay" system.

Ventilation.—Guibal fan, 36 feet by 12 feet.

Workings.—Longwall system.

Boilers.—Eight Lancashire.

Coal-washing Machine.—Sheppard's, to wash 200 tons in 11 hours.

Brick-works and Gas Works.

Richard Pit.

Winding Engine.—High Pressure Horizontal Engine; two cylinders, 20 inches and 22 inches diameter; stroke, 3 feet 6 inches; drum, 10 feet diameter; single deck cage, carrying two tubs 9½ cwts. of coals each.

Hauling Engine, Underground.—High Pressure Horizontal Engine; two cylinders, each 14 inches diameter; stroke, 20 inches; geared 5 to 1; clip pulleys; endless rope on side of tub; has been at work five years with the original rope; steam from surface.

Screens.—"Billy Fairplay" system.

Workings.—Longwall system.

Boilers.—Three Lancashire.

Relief Pit.

Winding Engine.—High Pressure Horizontal Engine; two cylinders, each 24 inches diameter, 4 feet 6 inches stroke; drum, 13 feet diameter; double deck cage; King and Humble's safety hook. This pit is used for changing men.

NEW HARTLEY.

WINDING ENGINE.—High Pressure Horizontal Engine; two cylinders, each 28 inches diameter, 4 feet 6 inches stroke; drum, 14 feet 4½ inches diameter; double deck cage, carrying four tubs, 8½ cwts. of coals each.

HAULING ENGINE, UNDERGROUND.—High Pressure Horizontal Engine; two cylinders, each 18 inches diameter, and 36 inches stroke; geared 2½ to 1; working endless chain; steam from surface.

PUMPING ENGINE.—Hathorn, Davey, & Co.'s Compound Differential Pumping Engine, on surface; high pressure cylinder, 24 inches diameter; low pressure cylinder, 44 inches diameter; stroke, 7 feet; working two rams at bottom, each 17½ inches diameter, 7 feet stroke, by means of quadrants and spears; pumping about 1,000 gallons per minute.

SCREENS.—"Yankee Jack" system.

VENTILATION.—Guibal fan, 30 feet by 10 feet.

WORKING.—Longwall system.

CRAB ENGINE.—One cylinder, 14 inches diameter, 30 inches stroke.

HYDRAULIC ENGINE.—Pumping from dip workings; one cylinder, 5½ inches diameter, 2 feet stroke; double-acting plunger, 9 inches diameter, 2 feet stroke.

BOREHOLE to Old Hester Pit workings; feeder, 800 gallons per minute.

BOILERS.—Eight Lancashire.

COWPEN COLLIERY.

WINDING ENGINE.—Horizontal; one 36-inch cylinder, 6 feet stroke; 14 feet drum.

Belts and jigging screen.

Robinson's Washer for cleaning small coal.

Endless rope haulage underground.

BEBSIDE COLLIERY.

A PIT.

WINDING ENGINE.—Condensing Vertical Single Cylinder, 50 inches diameter, 6 feet stroke; 18½ feet drum; cage with two decks, two tubs on each deck.

PUMPING ENGINE, UNDERGROUND.—Single Cylinder Horizontal High Pressure Engine; cylinder, 18 inches diameter, 3 feet stroke; 12-inch pumps; Cornish boiler, 20 feet by 6 feet, 1 tube.

B Pit.

Winding Engine.—High Pressure Horizontal Double Cylinder Engines; cylinders, 22 inches diameter, 5 feet stroke; 10 feet drum; double decked cage with single tub on each deck.

Pumping Engine at Bank.—Condensing, Single Cylinder, Vertical, 51 inches diameter; lifting set on each end of beam, which is 17 inches by 14 inches; stroke in cylinder, 6½ feet; stroke in pit, 8 feet 4 inches at one end and 6 feet 6 inches at the other.

Hauling Engine, Underground.—Double Cylinder Horizontal High Pressure; cylinders, 14 inches diameter, 2 feet 6 inches stroke; 5 feet drum, coupled 3 to 1; main and tail rope; 2 Galloway boilers, 18 feet by 6 feet; electric signals.

BEDLINGTON COLLIERY.

A Pit.

Winding Engines.—High Pressure Horizontal Single Cylinder Engine; jacketed; 40 inches diameter, 72 inches stroke; drum and pulleys, 15 feet; Ormerod's safety links; steam and foot brakes, and special indicator for signal raps.

Boilers.—Nine in number, seven double flued and two single flued; by Adamson & Co., Hawks, Crawshay, & Co., and Joicey & Co.; mostly 30 feet by 7 feet.

Pumping Engine.—Condensing, with beam working high set, 18 inches diameter, 47 fathoms; and low set, 20 inches diameter, and 59 fathoms; cylinder, 65 inches, stroke, 7½ feet.

Fan Engine.—Guibal fan, 30 feet by 12 feet with compound engines, 13 inches and 23¾ inches cylinders; also second or spare engine, 24 inches cylinder, high pressure.

Endless Rope Engines.—Two in number; a single 14 inch cylinder, with a stroke 24 inches, geared 8 to 1; rope passing three times round sheave which has an inclined trod; a pair of 12 inch cylinders, with a stroke of 24 inches, geared 10 to 1; rope passing round an 8 feet Barraclough patent-clip pulley.

Signalling.—In shaft, ordinary rapper for coal work. From mine to endless rope engines electric signals are used, double wires.

Heapstead.—Wrought iron; screens with ½-inch spaces and lowering boxes at ends, and "Billy Fairplay" system of weighing.

Workshops.—Are centralised and embrace the usual kinds, including granary and stables.

WORKINGS.—Longwall in Yard Seam.

SYSTEM OF HAULAGE.—A self-acting endless incline rope plane, 1,500 yards long, gradient of $1\frac{1}{4}$ inches in 36 inches, whereon 60 full tubs are run against 60 empty tubs, in 10 sets of 12 each; and the ordinary endless rope system, driven by steam, where the rope is carried on the top of the tub, with gradients varying from 6 inches per yard against to 3 inches in favour of the load, and with several junction stations. The length of rope in daily use in system last described is 8,500 yards, and the quantity of coals brought to pit bottom is 800 to 900 tons per day; the furthest off station is 1,570 yards.

CHOPPINGTON COLLIERY.

A PIT.

WINDING ENGINE.—High Pressure Horizontal Single Cylinder, 38 inches diameter, stroke, 5 feet 6 inches; four-valved; 14 feet drum; single deck cage for two tubs.

PUMPING ENGINE AT BANK.—Condensing Single Cylinder, 51 inches diameter, stroke, 6 feet 6 inches; stroke in pit, 8 feet 4 inches; one 18 inch lifting set on each end.

FAN ENGINE.—High Pressure Horizontal Single Cylinder, 20 inches diameter, stroke, 2 feet 6 inches; fan, 26 feet by 10 feet.

B PIT.

WINDING ENGINE.—High Pressure Horizontal Double Cylinders, each 22 inches, stroke, 5 feet; 10 feet drum; single deck cage for two tubs.

PUMPING ENGINE AT BANK.—High Pressure Vertical Single Cylinder, 51 inches diameter, 6 feet 6 inches stroke; 8 feet 4 inches stroke at both ends in pit; one 17 inch lifting set on each end.

FAN ENGINE.—High Pressure Horizontal Double Cylinders, each 20 inches diameter, stroke, 1 foot 8 inches; fan, 25 feet by 8 feet.

CAMBOIS COLLIERY.

WINDING ENGINE.—Lever Condensing; cylinder, 65 inches diameter, 6 feet stroke; drum, 22 feet diameter; round ropes; cage for 4 tubs; iron rail guides; Walker's safety links for prevention of overwinding.

Iron heapstead.

Steam crab.

UNDERGROUND PUMPING ENGINE.—Horizontal, 2 cylinders, each 22 inches diameter, 5 feet stroke; 2 feet 9 inch rams, forcing, 630 feet vertical.

UNDERGROUND HAULAGE.—Three of Fowler's semi-portable engines.

NORTH SEATON COLLIERY.

WINDING ENGINE.—Lever Condensing; cylinder, 60 inches diameter, 6 feet stroke; drum, 22 feet diameter; rope counter-balance under cages.

PUMPING ENGINE.—Condensing; cylinder, 78 inches diameter, 7 feet stroke; malleable iron beam by Fairbairn.

UNDERGROUND HAULAGE.—

Low Main Seam; tail rope; double horizontal engine, 2 cylinders, each 20 inches diameter, 4 feet stroke; drum, 8 feet diameter; length of plane, 3,200 yards.

Yard Seam; endless rope on self-acting plane.

ASHINGTON COLLIERY.

B.—Collieries in or about Newcastle-upon-Tyne.

KILLINGWORTH COLLIERY (CLOSED).

This is a very old colliery, which is not working, and is now partly dismantled. The points of interest are:—

George Stephenson's Cottage, with sun dial (constructed by the late Robert Stephenson, C.E.) above the front door.

Old Killingworth Railway.

The last of the old Killingworth Locomotive Engines, by Stephenson, the "Billy," is now placed on the north end of the High Level Bridge, Newcastle-upon-Tyne.

NORTH ELSWICK COLLIERY.

Compound Winding Engine.

Compound Pumping Engine; strain, 100 lbs. to the inch at a depth of 130 fathoms.

SOUTH ELSWICK COLLIERY.

BIRTLEY PATENT FUEL WORKS.

Complete plant for the manufacture of patent fuel, with coal-washers, etc., may be seen at work.

C.—Collieries situated on the Carlisle Line.

STELLA COLLIERY (ADDISON PIT).

Direct Acting Engine.
Compound Horizontal, Underground.
Coke Ovens.

THROCKLEY COLLIERY.

Compound Rotative Beam Pumping Engine, pumping 2,500 gallons per minute per 60 fathoms.
Coke Ovens.

WEST WYLAM COLLIERY.

TWO HAULING ENGINES.—One with 2 cylinders, 24 inches diameter and 4 feet 6 inches stroke, and one with 2 cylinders, 20 inches diameter and 4 feet 6 inches stroke, working main and tail rope.
Two Fans and Engines, 30 feet and 20 feet.
CONDENSING PUMPING ENGINE.—Cylinder, 42 inches diameter, 6 feet stroke; pumps, 20 inches diameter, 4 sets lifting.
Coke Ovens, etc.

PRUDHOE COLLIERY.

ONE HAULING ENGINE.—2 Cylinders, 18 inches diameter, each working a main and tail rope.

WYLAM COLLIERY (CLOSED).

This colliery was dismantled some years ago.
Locomotive engines were introduced by Mr. Hedley at this colliery about the year 1812. One of these is now placed in the South Kensington Museum.
George Stephenson was born at Street House, on the north side of the river, east from the station.

D.—South Shields and Sunderland Branches.

ST. HILDA COLLIERY.

WINDING ENGINES.—Double Cylinders, 36 inches diameter, 6 feet stroke; horizontal drum, 19 feet diameter; automatic expansion gear, made by the Grange Iron Co.; round steel ropes; cage at present for two decks, but arranged for four decks, with eight tubs (and double heapstead), safety links for prevention of over-winding.

PUMPING ENGINES.—Single Cylinder Vertical Condensing; cylinder, 65 inches diameter, 96 inches stroke; pumps, 12 inches diameter; sets lifting.

HAULING ENGINES, UNDERGROUND (WITH BOILERS AT SURFACE).—One Pair of Horizontal Engines; 2 cylinders, each 22 inches diameter, 36 inches stroke, working an engine-plane, with main and tail ropes, $2\frac{1}{4}$ miles long, with 100 tubs in each set.

SCREENING.—Belts with steel plates on ropes for screening best coals.

VENTILATION.—Guibal fan, 50 feet diameter, the largest erected.

WORKINGS.—Board and pillar system.

PATENT FUEL.—In course of erection, Yeadon's (of Leeds) system.

HARTON COLLIERY.

WINDING ENGINE.—Single Cylinder Vertical Condensing; cylinder, 65 inches diameter, 84 inches stroke; drum for flat steel ropes, 26 feet diameter; cage, three decks, with six tubs.

PUMPING ENGINE.—Single Cylinder Vertical Condensing; cylinder, 81 inches diameter, 120 inches stroke; pumps, 3 sets forcing rams, 15 inches diameter, 1 set lifting.

HAULING ENGINES ON SURFACE.—Main and tail ropes; ropes in boxes down shaft for 215 fathoms; electric signals and telephone from surface to bottom of shafts.

VENTILATION.—Guibal fan at St. Hilda Colliery.

WORKINGS.—Board and pillar system.

BOLDON COLLIERY.

WINDING ENGINES.—No. 1 PIT.—High Pressure Horizontal Double Cylinder Engines, 2 cylinders, steam-jacketed, each 48 inches diameter, 72 inches stroke; conical drum, 19 feet and 30 feet diameter; cage with four decks for eight tubs, 12 cwt. of coal in each tub; safety links for prevention of over-winding.

No. 2 Pit.—High Pressure Horizontal Double Cylinder Engines, 2 cylinders, each 40 inches diameter, 72 inches stroke; conical drum, 16 feet and 26 feet diameter; cage with two decks for four tubs; safety links for prevention of over-winding.

Hauling Engines Underground.—4 Double Cylinder Hauling Engines, with main and tail rope drums; electric signals; and three Lancashire boilers underground.

Screening.—Nine belts for cleaning coals; belt, 121 feet long, for carrying small coals to elevators for revolving screens.

Ventilation.—Large furnace, fired at side, and underground boilers.

Workings.—Large pillars, narrow places, lifts or juds.

Hydraulic Pumps in dip workings, actuated by water from rise workings.

Hydraulic Hoists at shaft bottom for lifting tubs from low level, together with self-acting arrangements for tubs.

MARSDEN COLLIERY.

Powerful Winding Engine, with two 48 inch cylinders.

Electric light plant, with 80 incandescent lamps.

Screens and endless belts.

Endless rope haulage.

Automatic ventilating doors.

WEARMOUTH COLLIERY.

Winding Engines.—Single Cylinder Vertical Low Pressure Condensing Engines; winding from a depth of 300 fathoms.

Underground Haulage.—Double Horizontal High Pressure Engines; long single and double way engine planes.

Ventilation.—Large furnace, fired in front and at sides.

E.—Collieries situated on the Sunderland and Hartlepool Branches.

SILKSWORTH COLLIERY.

Winding Engines.—

No. 1 Pit (Upcast).—Double High Pressure Horizontal Engines; cylinders, 20 inches diameter, with 3 feet stroke (temporary).

No. 2 Pit.—Double Horizontal High Pressure Engines; cylinders, 48 inches diameter, 6 feet stroke; cylindrical drums, 25 feet

diameter, with counter-balances; fitted with patent automatic expansion gear; cage, with four decks, containing eight tubs, each carrying ten cwts. of coal; pit, 270 fathoms deep.

No. 3 Pit.—Same as above, but with scroll drum, 15 feet to 28 feet diameter; pit, 290 fathoms deep.

Heapstead.—Double decked, with thirty-six screens and three circular revolving screens for separating the small coals.

Boilers.—Six cylindrical and eighteen Lancashire.

System of Haulage.—Main and tail rope; engine and boilers underground.

Underground Hauling Engines.—

Hutton Seam.—Double Horizontal High Pressure Engines; cylinders, 30 inches, 5 feet stroke, with four drums for main and tail rope system; air compressor attached; three cylindrical boilers underground.

Maudlin Seam.—Double High Pressure Horizontal Engines; cylinders, 18 inches and 26 inches stroke; three drums for main and tail rope systems; two multitubular boilers; a pair of small engines in-bye are worked by compressed air.

Ventilation.—Furnace.

Workings.—Board and pillar system.

RYHOPE COLLIERY.

Winding Engines.—North, South, and West Pits.—Three Low Pressure Vertical Condensing Engines, with cylinders 68 inches diameter, 84 inches stroke; rope roll at lift 21 and 22 feet diameter; cages, North and South Pits, two decks, with two tubs in each deck; West Pit, four decks, with one tub in each deck; 11 cwts. of coal in each tub.

Air Compressing Engine.—One Double Horizontal Air Compressing Engine, fitted with Walker's patent air valves; steam cylinders, 32 inches diameter; air cylinders, 33 inches diameter; 60 inches stroke; supplying compressed air to underground Hauling Engines.

Hauling Engines, Underground.—Two Horizontal Double Cylinder Hauling Engines; cylinders, 16 inches diameter, 24 inches stroke, with main and tail rope drums; geared 3 to 1 and worked by boilers of the locomotive type. Also various horizontal double hauling engines; cylinders, 14 inches diameter, 18 inches stroke, with main and tail rope drums, geared 4 to 1; worked by compressed air from engine at bank; electric signals.

SCREENING.—22 screens, with endless belts for conveying small coal from screens to apparatus.

VENTILATION.—Three furnaces, fired in front; area of grate, one 112 square feet, and two each 56 square feet.

WORKINGS.—Board and pillar system; pillars, 40 yards by 30 yards.

COKE OVENS and coal washing machine; the "Ramsay Washer."

HORSE FEED.—Mixed system as carried out by Mr. Hunting.

SEAHAM AND SEATON COLLIERIES.

WINDING ENGINES—

NOS. 1 AND 2 PITS.—Single-acting Low Pressure Cylinders, 67 inches diameter and 7 feet stroke, with 21 feet drums; erected in 1849–50, and raising each 850 tons a day.

No. 3 PIT.—Single-acting Low Pressure Cylinder, 69 inches diameter and 7 feet stroke, with 21 feet drum; erected in 1869, and raising 1,500 tons a day.

SYSTEM OF HAULAGE.—Tail rope, with sets of 60 tubs; engines and boilers underground—

No. 1 PIT.—Pair of Double-acting Cylinders, 19 inches diameter and 3 feet stroke; with 7 feet drums geared 8 to 3.

No. 2 PIT.—Pair of Double-acting Cylinders, 19 inches diameter and 3 feet 6 inches stroke, with 6 feet drums geared 3 to 2, an auxiliary engine being employed to bring the coals from the face to mid distance. This auxiliary engine is worked by compressed air of 50 lbs. pressure, and has a pair of 16 inch cylinders.

No. 3 PIT.—Maudlin Seam.—This engine is at bank, with ropes carried down the shaft in pipes, and has a pair of 26 inch cylinders and 5 feet stroke, supplied with steam at 100 lbs. pressure.

There are over 33,000 yards of rope used for hauling purposes.

AIR COMPRESSORS are in course of erection for working the No. 2 Pit auxiliary hauling engine, and nearly a score of small pumps. The steam and air cylinders are 44 inches diameter and 6 feet stroke.

VENTILATION by one return air and one fresh air furnace and numerous boilers, producing a current of 350,000 feet per minute. The furnaces consume 20 tons of coal per day. The hanging on of the coal at No. 3 Upcast Pit is done in fresh air, prevented from passing up the shaft by means of automatic doors worked by the cages, which are boxed to prevent leakage.

Upwards of 2,300 men and boys are employed, living in nearly 1,000 houses, and the underground men requiring over 2,100 lamps.

Electric signals and telephones are used.

The Fleuss breathing apparatus and lamp are kept ready for immediate use.

Little or no dust is seen on the engine planes owing to the use of watering pipes, and more especially to the watering of tubs of coal before leaving the face.

Self-registering water barometer in connection with a small sealed area of workings is used. The variations of pressure from 1 inch to 22 inches in this confined space presage a fall of atmospheric pressure much in advance of a mercurial barometer. This instrument was devised by Mr. V. W. Corbett, and the results form a continuation of his valuable paper in Vol. XXXII. of the Institute Transactions.

Brickworks.—Hoffmann's Patent Annular Kiln is used, having twelve sections, each burning 18,000 bricks. The fortnightly produce is 130,000.

SOUTH HETTON AND MURTON COLLIERIES.

SOUTH HETTON.

Winding Engine.—North Pit.—Vertical Condensing Engine; cylinder, 45½ inches diameter, 6 feet stroke; flat rope drum, 18 feet diameter; cages with three decks each to hold three tubs, 10 cwts. of coal in each tub.

Winding Engine.—South Pit.—Vertical Condensing Engine; cylinder, 42 inches diameter, 6 feet stroke; flat rope drum, 18 feet diameter; cages with two decks, each to hold two tubs, 10 cwts. of coal in each tub.

Hauling Engines, on Surface.—High Pressure Vertical Lever Engine; cylinder, 30 inches diameter; stroke, 4 feet; main and tail rope drums. Ropes in boxes down shafts.

Underground.—Pair of Horizontal High Pressure Engines; cylinders, 14 inches diameter, 18 inches stroke; auxiliary cylinder, 12 inches diameter; main and tail rope drums.

Pumping Engine, Underground.—Pair of Rotary High Pressure Engines; cylinders, 27 inches diameter; stroke, 48 inches; rams, 8 inches diameter; head of water, 140 fathoms in one column; rising main, 8 inches diameter.

Ventilation.—Furnace in Low Main Seam.

Workings.—Board and pillar system.

MURTON.

WINDING ENGINE.—POLKA PIT.—Single Cylinder Vertical Condensing; cylinder, 50⅜ inches diameter; stroke, 7 feet; drum, 18 feet 8 inches; flat ropes; cage four decks, four tubs.

WINDING ENGINE.—MIDDLE PIT.—Vertical Condensing; cylinder, 50⅜ inches; stroke, 7 feet; drum for flat steel ropes, 18 feet 4 inches diameter; cage four decks, four tubs.

WINDING ENGINE.—EAST PIT.—Vertical Condensing; cylinder, 50⅜ inches diameter; stroke, 6 feet; drum 16 feet 10 inches; cage four decks, four tubs; cages unloaded on platforms.

PUMPING ENGINE AT BANK.—Single Vertical Condensing; cylinder, 84½ inches diameter; stroke, 8 feet 8½ inches; pumps, 16 inches diameter; 6 sets lifting and 1 set forcing.

UNDERGROUND PUMPING ENGINE.—Two Hathorn and Davy's Double-acting Differential Condensing Engines; steam cylinders, 32 inches diameter; rams, 7¾ inches diameter; stroke, 5 feet; rising main, 10 inches diameter; capable of forcing 400 gallons per minute in one column 1,224 feet.

SYSTEM OF HAULAGE.—Tail rope; hauling engines underground.

MAIN COAL SEAM.—Horizontal High Pressure Double Cylinders, 26 inches diameter; stroke, 5 feet; four drums, 7 feet diameter,

LOW MAIN SEAM.—Horizontal Double Cylinders, 26 inches diameter; stroke, 5 feet; four drums, 7 feet diameter.

MIDDLE PIT, HALLFIELD.—Horizontal Double Cylinders, 18 inches diameter; stroke, 24 inches; drums, 6 feet diameter.

EAST PIT, HAWTHORN.—Horizontal Double Cylinder, 30 inches diameter; stroke 5 feet; drums, 8 feet diameter; engine plane, 2⅓ miles long; 52 tubs in each set.

HYDRAULIC ENGINE.—Horizontal Double Cylinder, 16 inches diameter; stroke, 20 inches; four drums, 5 feet diameter.

UNDERGROUND BOILERS.

VENTILATION.—Two Furnaces in Main Coal Seam; large furnace, 33 feet by 8 feet, stoked at sides and end; small furnace, 8 feet by 7 feet.

WORKINGS.—Board and pillar and longwall.

COAL WASHER.—Robinson's Patent, in course of erection.

WINGATE GRANGE COLLIERY.

COMPOUND CONDENSING PUMPING ENGINE.—Cylinders, 40 inches and 66 inches by 6 feet stroke; rams, 16 inches, forcing against a head of 810 feet; now pumping 1,300 gallons per minute.

TWIBILL'S PATENT FUEL ECONOMISER.—At work on four Lancashire Boilers. Temperature of feed water raised from 50 degrees to 180 degrees.

Exhaust Injector attached to fan engine.

Guibal fan, 36 by 12.

Schiele fan, 12 feet diameter.

Winding Rope, with Electrical Cable, for signalling out of the cage in the shaft to engineman.

HAULING ENGINE.—Direct acting; two 20 inch cylinders, 4 feet stroke; drums, 5 feet diameter.

CASTLE EDEN COLLIERY.

WINDING ENGINE.—OLD PIT.—Vertical High Pressure Engine; one cylinder, 42 inches diameter, 72 inches stroke; drum, 17 feet diameter.

WINDING ENGINE.—NEW PIT.—Horizontal Engine; two cylinders, each 36 inches diameter, 72 inches stroke; condensing and air pump, worked by independent engine; drum 20 feet diameter.

VENTILATION.—By Guibal Fan, driven by engine with one cylinder 24 inches diameter and 48 inches stroke; condensing, and worked by same air pump as winding engine.

AIR COMPRESSING ENGINE.—Horizontal Condensing Engine; two cylinders 36 inches diameter, and two air cylinders 40 inches diameter, 72 inches stroke.

SCREENING.—Jigging Screen, 11 feet by 4 feet, with belt for cleaning best coal, 60 feet long and 4 feet wide, also belt for cleaning nut coal, 24 feet long and 2 feet wide.

Boilers on coke ovens, also boilers with mechanical stokers.

Coal washed for coke making by Ramsay's machine.

UNDERGROUND HAULAGE.—Horizontal Engine; two cylinders, 18 inches diameter, 24 inches stroke, geared seven to one, and driving about 10,000 yards of endless rope, which is carried on rollers, each tub being attached to the rope by a clip. There are three branch roads worked off the main rope by Fisher & Walker's clutch gear.

UNDERGROUND PUMPING ENGINE.—Horizontal Compound and Condensing; High Pressure cylinder, 42 inches diameter; low pressure cylinder, 66 inches diameter, 72 inches stroke, and 14 inch ram, double-acting; forcing water from Low Main Seam to the surface, a height of 900 feet.

F.—Collieries situated on the Leamside Line.

NEWBOTTLE COLLIERIES.

HERRINGTON.

No. 1 Pit.

Winding Engine.—Low Pressure Vertical Cylinder, 54 inches diameter, 84 inches stroke; drum, 18 feet diameter; cage with two decks of 3 tubs each, 9 cwt. of coal in each tub; total weight of cage, tubs, and coals, 7 tons. Steel wire ropes; safety links for prevention of over-winding.

Shaft fitted with iron rail guides.

Iron heapstead, and screens; Archimedean screw, carrying small coals to self-loading apparatus hopper; screen for making large nuts, small, and duff.

Two underground hauling engines, working tail rope system; endless chain; incline near to shaft.

Electric light at bank and underground.

No. 2. Pit.

Winding Engine.—Double Horizontal Air Compressing Engine, 22 inch cylinder, 36 inches stroke; diameter of larger compressing cylinder 36 inches, diameter of smaller cylinder 13½ inches; nominal pressure of air 200 lbs. per square inch.

Ventilating furnace at Maudlin Seam; one front fire and two side fires.

Systems of Working.—Longwall and board and pillar.

Boilers, with Young's patent fires.

LAMBTON.

D Pit.

Lishman & Young's Compressed Air Locomotives at work underground.

Air Compressing Engine at Bank.—Two 34 inch cylinders with 6 feet stroke, working 2 air compressing cylinders, 34 inch pressing to 60 pounds, and 20 inch completing the pressure to 250 pounds per square inch.

HOUGHTON COLLIERY.

FAN ENGINE.—Two cylinders, 36 inches diameter and 3 feet stroke; Guibal fan, 45 feet diameter, 15 feet wide.

WINDING ENGINES.—

NEW PIT.—Two cylinders, 34 inches diameter, 6 feet stroke, with 18 feet drums, lifting four tubs.

WEST SIDE.—One cylinder, 35 inches diameter, 6 feet stroke, with 12 feet rolls, lifting three tubs.

EAST SIDE.—One cylinder, 33 inches diameter, 6 feet stroke, with 14 feet drums, lifting four tubs.

STAPLE.—One cylinder, 14 inches diameter, 28 inches stroke, with 5 feet drums, lifting one tub.

HAULING ENGINES.—

HUTTON SEAM.—Two cylinders, 18½ inches diameter, 3 feet stroke, with 5 feet drums, running 70 tubs.

MAIN COAL SEAM.—Two cylinders, 24 inches diameter, 4 feet stroke, with 7 feet drums, running 100 tubs.

STAPLE.—One cylinder, 14 inches diameter, 2 feet stroke, with 3 feet drums, running 15 tubs.

MAIN COAL PUMPING ENGINE.—One cylinder, 52 inches diameter, 5 feet stroke, with two 10½ inch rams, lifting 610 feet, and two 11½ inch rams, lifting 480 feet, 680 gallons per minute.

IN-BYE PUMP IN MAIN COAL SEAM.—Two 7 inch plungers, double-acting, 100 lbs. pressure at pump, 360 gallons per minute, worked by endless rope from Main Coal Seam Hauling Engine, geared 2 and 1 at engine, and 2 and 1 at pump, situate 3,000 yards in-bye and lifting 200 feet. This rope has been five years and three months in use, is 6,000 yards long, has travelled over 218,400 miles, and has pumped 318,998,400 gallons of water.

G.—Collieries in or about Durham.

BROWNEY COLLIERY.

Boilers fired from Coke Ovens.

Coals crushed by disintegrator, and cleaned on a travelling belt.

Ventilation by Schiele fans, placed in each seam.

Haulage, in Busty Seam, by endless rope.

BEARPARK COLLIERY.

WINDING ENGINE.—Vertical cylinder, 56 inches diameter.
Revolving Screens and Roller Crushers.
Hauling Engine on surface.
Guibal Ventilating Fan.
PUMPING ENGINE.—Horizontal surface; 36 inches cylinder, 5 feet stroke, and 21 sets in shaft.
UNDERGROUND PUMPING ENGINE.—Four rams, 11½ inches, with four cylinders, 26 inches, forcing to surface.
Beehive Coke Ovens, loaded by small narrow gauge Locomotive Engines.
Boilers on Coke Ovens.
Simon Carvé's Coke Ovens.
Gas Plant in connection with Patent Coke Ovens.
Sulphate of Ammonia Plant.

NEW BRANCEPETH COLLIERY.

Cochrane's Patent Coke Ovens, of beehive type, which enables them to be drawn three times a week and yields from 5 to 6 per cent. extra of coke.

FRIDAY, AUGUST 5TH.

EXCURSION DOWN THE RIVER.

A large party assembled at the Swing Bridge and inspected the machinery.

Special steamers (free to members) were kindly placed at the disposal of the visitors by the River Tyne Commissioners and Mr. John Rogerson, and proceeded down the river, stopping to allow visitors to inspect such works as they desired, which had been thrown open to them, viz.:—

The Newcastle Chemical Works, Ld.
R. & W. Hawthorn, Leslie, & Co., Ld. (St. Peter's.)
Charles Tennant & Partners, Ld., Hebburn.
Palmer's Shipbuilding and Iron Co., Ld., Jarrow.
Addison Potter & Son's Cement Works, Willington.
The Northumberland Dock.
The Tyne Dock. (Shipping of Coals, &c.)
The Albert Edward Dock.

On the steamer arriving at South Shields, the visitors had an opportunity of inspecting the Tyne Commissioners' works there and at Tynemouth.

SATURDAY, AUGUST 6TH.

This morning parties were formed at the reception room to visit the following works in Newcastle and Gateshead, which were open for inspection :—

R. & W. Hawthorn, Leslie, & Co., Ld., Engineering Works, Forth Banks, Newcastle.

Robt. Stephenson & Co., Ld., Engineering Works, Forth Street, Newcastle.

Haggie Bros., Rope Works, Gateshead.

Black, Hawthorn, & Co., Engineering Works, Gateshead.

Many visitors attended the Annual General Meeting of the North of England Institute of Mining and Mechanical Engineers, at the Theatre of the Exhibition in the Afternoon, when the Presidential Address was delivered by Sir Lowthian Bell, Bart.

Mr. Theo. Wood Bunning also read a paper "On the Federation of the Mining Institutes of Great Britain."

HAULAGE EXHIBITS IN THE NORTH GARDENS OF THE EXHIBITION.*

Various principles of haulage have been generally adopted in different parts of the United Kingdom, and it was thought by the Executive Council of the Exhibition that it would form a very interesting exhibit to the mining world to bring together, if possible, all the leading methods that have been successfully used. A committee was appointed to carry out this object, and the results of their labours are seen in what is called the Haulage Exhibit. The committee decided that none would be considered of sufficient importance or general utility unless they could be automatically worked round a curve, which explains the absence of several well-known arrangements.

1.—ENDLESS CHAIN.—Double way; single tubs travelling at fixed distances from each other; self-acting arrangement of inclines at curve for both full and empty tubs.

Erected and exhibited by the Tyne Coal Company, Limited, under the superintendence of Mr. Charles A. Shute.

2.—ENDLESS ROPE.—Single way, with pass-byes or sidings; rope under tubs; tubs run in sets.

* A more minute description of the whole of the Haulage Exhibits is being prepared by Mr. G. May, and will be printed in the next volume.

TYNEMOUTH
Tynemouth Lighthouse
RIVER TYNE COMM^RS
NORTH PIER
PIER WORKS
Black Middens
THE NORTH SEA
SOUTH PIER
HERD SAND
RIVER TYNE COMM^RS
WORKS
Drow Rocks
Frenchmans Bay
Westoe
RIVERSIDE
Magnetic North
True North
Variation
21° 0'
Marsden Bay
Marsden Sands
ANDREW REID, LITH, NEWCAST

A most interesting system of haulage, consisting of a line of single way with a siding half way along the plane. The empty tubs are drawn from the shaft to the central siding at the same time as the full tubs are drawn from the in-bye station to the same place. The full tubs are then attached to the rope which hauled the empty tubs to the siding, and the empty tubs are attached to the rope which hauled the full tubs to the same place. The engine is then reversed, the full tubs hauled to the shaft, and the empty tubs to the in-bye station.

Erected and exhibited by the Moresby Coal Company, Limited, Whitehaven, who have supplied the tubs, etc.; the Lowca Engineering Company, Limited, Whitehaven, have supplied the engine, etc., and the Moss Bay Hematite Iron and Steel Company, Workington, have supplied the steel rails and sleepers.

3.—ENDLESS ROPE.—Double way; rope on top of tubs run singly at fixed distances from each other.

It is worked very successfully at Bedlington Colliery, and is exhibited to show the application of a very ingenious method of passing the rope round curves in forks on the top of the tubs without being disengaged. This is done by having a number of large pulleys placed in a horizontal position round the curve to carry the rope. A self-acting gate, with a roller on the top, is fixed at each end of the curve to lead the rope on to the horizontal pulleys.

Erected and exhibited by the Bedlington Coal Company under the superintendence of Mr. J. G. Weeks.

4.—ENDLESS ROPE.—Double way; rope on side of tubs, and tubs run singly at distances of about 20 yards from each other. The rope is attached to the side of the tubs and is successful in passing round the curve.

Erected and exhibited by the Seaton Delaval Coal Co., under the superintendence of Mr. R. E. Ornsby.

5.—ENDLESS ROPE.—Double way; tubs run in sets of 14, having a bogey with a fixed clip for attachment to rope travelling in front of set; rope under tubs.

Employed at South Durham Colliery, in the county of Durham, on an engine plane about 4,000 yards long.

Erected and exhibited by the South Durham Coal Co., under the superintendence of Mr. Fenwick Darling.

6.—ENDLESS ROPE.—Double way; rope under tubs with single tubs travelling at fixed distances from each other.

Shows the application of clips passing round curves with the rope underneath the tubs.

A very ingenious arrangement for automatically disengaging the clips from the rope is shown here.

Erected and exhibited by the Castle Eden Coal Co., under the supervision of Mr. J. F. Lee.

7.—Endless Rope.—Three-rail way with pass-byes and sidings, rope under tubs, and tubs run in sets.

The tubs are attached (in sets of about fourteen) to the rope by clips. The sets are moved from siding to siding, passing each other at the pass-byes; they are then stopped, an empty set being disengaged and a full set attached at the in-bye end, and *vice versâ* at the out-bye end. It is most important to attach the set of tubs exactly opposite the part of the rope from which the other set has been detached.

Erected and exhibited by the Harton Coal Company, Limited, under the superintendence of Mr. George May.

8.—Endless Rope.—Double way; rope under tubs, and tubs run singly at fixed distances from each other.

This exhibit explains the application of clips passing round curves with the rope underneath the tubs, and is erected by the Whitburn Coal Company, Limited, under the superintendence of Mr. M. H. Douglas.

The Fleeting pulleys and clutch gear used and the automatic ventilation door are worthy of close attention.

9.—Tail Rope.—Single way; rope under tubs; tubs run in sets.

This system of haulage has attained a very high degree of perfection in the North of England, where, until a few years ago, it was almost the only method in use. The exhibit, erected by the Hetton Coal Company, Limited, under the superintendence of Mr. Thomas Lishman, shows the general method of working; the main rope being used for hauling the full tubs from the workings to the shaft, and the tail rope for hauling the empty tubs from the shaft to the workings.

The engine used for this exhibit has been manufactured by the Grange Iron Company, Limited, Durham, and consists of a self-contained double cylinder engine, having cylinders 12 inches diameter and 15 inches stroke, with two drums, each 4 feet diameter. The drums can be run loose or fast by clutch attachment.

10.—Endless Rope.—Double way; single tubs travelling at fixed distances from each other; rope under tubs, attached by clips of various forms. Two lines of rails are used, one for the empty and the other for the full tubs. The leading feature is the slow, continuous motion of the rope, which travels about 2½ miles an hour. The tubs are attached singly to the rope by Fisher's patent or by Rice's patent hook, and the

rope can be loaded from end to end with tubs placed 6 feet apart. Under these conditions it is capable of delivering 2,000 tubs per hour.

Exhibited by the Hodbarrow Mining Company, under the supervision of Mr. Cedric Vaughan.

11.—Wire Rope Way.—For transport, in the case of mines separated by rivers or ravines from the place where the mineral is used or treated.

This is shown at work by Messrs. Jordan, Son, & Commans, near to the toboggan slide, at the north-west corner of the grounds.

12.—Air Locomotive (Lishman & Young's system).—Single way; tubs run in sets.

Successfully worked at the Earl of Durham's collieries in the county of Durham, and may be seen in operation at the Lambton Colliery D pit.

The Air Locomotive has four wheels, running on a gauge of 2 feet 9½ inches; and two cylinders, each 4 inches diameter and 7 inches stroke, working at a pressure of 400 lbs. per square inch.

The Air Compressor consists of a vertical engine, having two steam cylinders, 12 inches diameter; and two air cylinders, 8 inches diameter. The air is compressed in two stages, being taken in from the atmosphere on the top of the piston, and compressed through water spaces into an annular space on the underside of the piston: it is then delivered, through a copper coil immersed in a water tank, to a receiver, standing on the ground from which the locomotive receives its supply.

On leaving the compressing cylinder the air passes through a trap pipe, where all the water is separated, and can be blown off occasionally, only dry air being delivered into the receiver.

13.—Endless Rope.—Single way, with pass-byes or sidings; rope under tubs and tubs run in sets.

Successfully employed at many of the Tredegar Iron and Coal Company's collieries, and explains the method of working an endless rope on a single line of way, with convenient places for the sets to pass each other. Both ropes are carried, about 6 inches apart, by suitable rollers between the rails. The set of tubs is coupled to a bogey which is attached to the rope by clips or tongs.

Erected and exhibited by the Tredegar Iron Co., under the superintendence of Mr. Hamilton.

The steam for working the whole of the systems is supplied by Robey & Co.'s well-known form of locomotive boiler.

Eight of the systems are driven by a hauling engine provided by Messrs. Walker Bros., of Wigan.

Fisher and Walker's patent friction clutches and pulleys are attached to the above engine and to the No. 7 exhibit.

The steel rails were lent by Mr. Edward Sisterson, of Newcastle.

The ropes are supplied by the Hartlepool Ropery Co.

With one exception electric signals are employed, provided by Messrs. John Mills & Son, Newcastle.

Several forms of automatic tub greasers are at work.

The whole of the details have been carried out by a small committee of mining engineers, under the presidency of Mr. George May, manager of the St. Hilda, Harton, and Boldon Collieries.

COAL MINE AT THE EXHIBITION.

The representation of a coal mine in the North Gardens of the Exhibition is worth inspection.

The entrance to the pit in a few yards leads the visitor to the bottom of the shaft where one cage is shown in position.

A Fowler's Improved Compound Semi-Portable Engine and Boiler is situated near the shaft, and is used for hauling the tubs along the engine plane. This is arranged for one of the systems of endless rope haulage, where the rope is suspended above the tubs by means of forks, of which several varieties are used, but Messrs. Rutherford and Thompson's patent clip forks (of numerous patterns) are most worthy of mention. A working model of this mode of haulage, working automatically round a right angled curve, is shown at Stand 601 in the West Court.

Next to the hauling engine the Union Engineering Co. show a Schiele Fan in the pit, which in practice is usually placed on the surface.

The lighting of the coal mine is gratuitously supplied by Messrs. Clarke, Chapman, Parsons, & Co., of Gateshead. 16 candle-power lamps are used, placed in air-tight fittings to avoid igniting explosive mixtures of gas and air if the connection of the lamp to the conductor should be interrupted. The dynamo, running at the high speed of 9,000 revolutions per minute, is driven directly by a series of steam turbines on the same bed-plate.

At the end of the engine plane "the landing" is reached, from which the tubs are brought to and from the workings by hand-putters or pony drivers.

Up to this point the seam is represented as being 6 feet thick, and the visitor proceeds through a trouble into a thinner seam of coal. This is worked on the longwall system, which consists of removing the whole of the coal, packwalls being inserted at intervals between, and on each side of the roads, to carry the roof.

The visitor returns through the fault into the thicker seam. This is wrought on the board or pillar system, the boards being 15 feet wide and crossed at right angles by walls 7 feet wide. The mode of removing the pillars is shown in the broken or second working.

An example of post and stall work is also shown. In this system the places are from 12 to 15 yards wide, with an equal width of coal between, packwalls being built in the middle to support the roof, and the coals brought out on roads left on each side of the places. When these places are carried to the required distance the intervening ribs of coal are removed.

A large fault is here supposed to exist, which throws the Lead-Measures against the Coal-Measures.

LEAD MINE AT THE EXHIBITION.

The visitor passes from the coal mine into one of the levels driven on the vein and connected with the surface by means of the adit. Part of one of these levels, owing to the loose strata, is piled on the top and sides.

By means of these levels going in opposite directions the vein is opened out and proved, and when the "ends" are far enough advanced stopes are set off and the ore ground above the level is worked. The stopes are pushed forward like inverted stairs, allowing space for the respective sets of workmen on the steps.

The shaft is shown in this and the upper levels, fitted with cages for drawing the minerals and workmen, with pumps for raising the water, and a ladder-way for the use of workmen.

The horse track or inclined drift, for the passage of horses, is used by visitors as an access to the upper level of the mine.

The ore from these higher workings may be drawn at the shaft or allowed to fall through hoppers or shoots to the level of the adit, whence it is taken to the surface by means of wagons drawn by manual labour or ponies.

BAROMETER AND THERMOMETER READINGS FOR 1886.

By the SECRETARY.

THESE readings have been obtained from the observations of Kew and Glasgow, and will give a very fair idea of the variations of temperature and atmospheric pressure in the intervening country, in which most of the mining operations in this country are carried on.

The Kew barometer is 34 feet, and the Glasgow barometer 180 feet above the sea level. The latter readings have been reduced to 32 feet above the sea level, by the addition of ·150 of an inch to each reading, and both readings are reduced to 32 degrees Fahrenheit.

The fatal accidents have been obtained from the Inspectors' reports, and are printed across the lines, showing the various readings. The name of the colliery at which the explosion took place is given first, then the number of deaths, followed by the district in which it happened.

At the request of the Council the exact readings at both Kew and Glasgow have been published in figures.

BAROMETER READINGS, &c.

JANUARY, 1886.

	KEW.						GLASGOW.					
	Barometer.				Temperature.		Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·063	30·073	30·008	29·990	49·6	44·2	29·741	29·711	29·618	29·574	50·6	47·4
2	29·923	29·946	29·944	30·030	51·3	39·3	29·643	29·692	29·767	29·831	50·3	38·8
3	30·062	30·016	29·883	29·802	50·1	31·4	29·743	29·452	29·330	29·386	49·0	38·3
4	29·701	29·699	29·624	29·618	49·5	41·3	29·387	29·366	29·289	29·205	41·8	32·2
5	29·607	29·667	29·583	29·642	41·3	36·2	29·155	29·135	29·401	29·590	39·9	29·5
6	29·628	29·522	29·678	29·869	38·3	28·1	29·668	29·823	29·936	30·033	33·3	25·0
7	29·988	30·090	30·062	29·992	28·3	16·0	30·026	29·916	29·613	29·275	38·0	19·4
8	29·695	29·550	29·606	29·670	35·0	16·5	29·329	29·428	29·548	29·663	35·0	28·0
9	29·718	29·782	29·900	30·020	35·4	25·8	29·824	29·953	29·998	30·027	36·1	27·4
10	30·034	30·055	29·982	29·887	33·5	30·3	29·972	29·870	29·718	29·620	34·4	25·7
11	29·763	29·739	29·845	30·032	39·1	33·6	29·667	29·840	30·007	30·103	42·6	31·4
12	30·096	30·126	30·020	29·849	36·5	29·8	30·082	29·900	29·701	29·580	48·0	30·6
13	29·635	29·229	29·263	29·420	44·1	36·2	29·173	29·199	29·325	29·709	49·4	34·2
14	29·636	29·837	29·920	29·981	41·2	30·9	29·879	29·921	29·739	29·541	47·1	29·6
15	29·882	29·790	29·587	29·543	46·5	31·3	29·371	29·287	29·209	29·186	49·2	32·5
16	29·594	29·710	29·668	29·426	42·9	33·7	29·229	29·267	29·016	28·948	43·1	31·3
17	29·434	29·480	29·347	29·177	42·2	33·9	28·990	29·000	28·913	28·866	35·2	29·3
18	28·969	29·003	29·076	29·202	39·9	30·0	28·829	28·944	28·988	29·055	31·7	18·9
19	29·259	29·319	29·322	29·382	35·2	25·6	29·116	29·303	29·235	29·229	34·0	19·8
20	29·432	29·505	29·509	29·461	33·1	28·1	29·468	29·626	29·652	29·688	36·3	23·4
21	29·338	29·323	29·341	29·400	35·0	30·4	29·653	29·634	29·634	29·648	36·3	25·8
22	29·437	29·521	29·541	29·565	34·2	30·8	29·603	29·644	29·721	29·773	37·2	25·5
23	29·468	29·430	29·379	29·393	35·9	32·0	29·746	29·685	29·619	29·629	37·9	27·4
24	29·409	29·457	29·462	29·421	37·0	30·3	29·570	29·546	29·498	29·480	35·5	31·8
25	29·296	29·302	29·285	29·261	40·4	33·2	29·520	29·523	29·434	29·470	37·0	29·7
26	29·234	29·524	29·575	29·676	44·0	35·1	29·490	29·560	29·587	29·625	37·1	29·9
27	29·728	29·803	29·822	29·872	44·0	30·0	29·681	29·782	29·809	29·858	38·6	31·3
28	29·876	29·889	29·868	29·855	43·6	28·2	29·775	29·738	29·658	29·577	39·9	32·7
29	29·760	29·626	29·478	29·633	42·9	34·9	29·444	29·368	29·329	29·446	39·1	33·9
30	29·771	29·716	29·482	29·478	44·2	33·0	29·393	29·249	29·056	29·059	38·6	30·0
31	29·449	29·189	29·160	29·356	46·4	35·0	28·916	28·847	28·931	28·933	34·9	27·6

FEBRUARY, 1886.

1	29·262	29·244	29·321	29·407	42·0	36·1	28·945	28·987	29·164	29·235	35·0	28·4
2	29·500	29·564	29·596	29·618	42·6	34·3	29·300	29·389	29·429	29·429	38·6	31·9
3	29·529	29·492	29·573	29·770	38·0	33·4	29·426	29·556	29·695	29·898	37·2	24·8
4	29·946	30·115	30·177	30·247	39·3	32·8	30·067	30·202	30·252	30·311	33·5	17·4
5	30·233	30·204	30·066	29·982	36·8	30·8	30·256	30·128	29·962	29·967	34·5	15·3
6	30·007	30·127	30·161	30·282	37·1	27·2	30·028	30·111	30·130	30·140	35·0	29·7
7	30·333	30·441	30·482	30·597	35·4	26·0	30·153	30·192	30·212	30·297	39·1	32·7
8	30·622	30·707	30·669	30·721	35·1	27·7	30·355	30·448	30·438	30·451	50·2	37·3
9	30·690	30·690	30·609	30·579	35·9	22·9	30·405	30·420	30·370	30·334	45·0	42·4
10	30·504	30·472	30·360	30·327	31·3	22·2	30·287	30·301	30·264	30·247	45·0	37·5
11	30·233	30·174	30·079	30·044	36·2	28·9	30·141	30·043	29·888	29·833	42·3	35·4
12	30·002	29·988	29·923	29·953	42·6	35·1	29·779	29·752	29·684	29·635	45·0	37·6
13	29·926	29·919	29·883	29·872	47·5	35·8	29·608	29·574	29·504	29·484	46·1	42·5
14	29·783	29·768	29·803	29·916	42·6	36·3	29·451	29·540	29·648	29·798	43·7	33·8
15	29·955	29·993	29·963	29·969	40·0	34·7	29·907	30·014	30·034	30·083	39·0	31·5
16	29·934	29·935	29·890	29·909	37·7	33·8	30·066	30·084	30·035	30·045	37·2	31·1
17	29·905	29·939	29·980	30·061	35·9	32·9	30·029	30·066	30·107	30·203	39·8	33·6
18	30·085	30·119	30·088	30·106	37·2	32·9	30·219	30·273	30·223	30·181	37·3	33·9
19	30·077	30·087	30·066	30·104	34·0	32·8	30·091	30·052	30·013	30·034	35·0	31·1
20	30·120	30·156	30·154	30·182	35·0	31·9	30·036	30·045	30·041	30·089	34·5	31·8
21	30·178	30·221	30·235	30·298	36·5	31·7	30·103	30·144	30·154	30·208	37·4	33·2
22	30·335	30·382	30·353	30·363	37·0	28·7	30·235	30·269	30·273	30·319	38·5	35·4
23	30·321	30·301	30·224	30·208	33·9	28·6	30·333	30·353	30·271	30·275	37·4	30·9
24	30·173	30·150	30·097	30·107	34·0	25·5	30·225	30·206	30·155	30·193	35·0	29·5
25	30·095	30·103	30·094	30·117	35·2	30·4	30·181	30·204	30·195	30·230	35·7	27·2
26	30·136	30·213	30·213	30·248	38·5	27·4	30·234	30·282	30·262	30·266	35·2	26·6
27	30·251	30·257	30·219	30·240	38·4	27·0	30·183	30·237	30·214	30·264	37·2	25·8
28	30·218	30·219	30·157	30·090	32·2	29·7	30·281	30·285	30·203	30·123	35·1	30·8

BAROMETER READINGS, &c.

MARCH, 1886.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·896	29·734	29·530	29·324	38·4	30·7	1	29·943	29·829	29·684	29·589	33·2	27·2
2	29·311	29·299	29·249	29·221	39·9	32·4	2	29·475	29·443	29·431	29·503	31·8	26·4
3	29·263	29·453	29·703	29·816	34·2	29·9	3	29·622	29·738	29·777	29·782	39·2	27·2
4	29·824	29·843	29·776	29·694	39·2	26·0	4	29·713	29·628	29·573	29·537	39·7	33·3
5	29·452	29·291	29·233	29·324	38·1	30·2	5	29·432	29·381	29·362	29·435	36·7	28·7
6	29·479	29·672	29·890	30·077	38·4	28·2	6	29·586	29·780	29·910	30·042	35·2	24·2
7	30·154	30·217	30·211	30·241	36·7	22·3	7	30·096	30·146	30·138	30·155	33·7	21·1
8	30·244	30·296	30·307	30·372	40·2	24·9	8	30·142	30·162	30·170	30·225	38·6	26·8
9	30·367	30·374	30·340	30·336	42·6	26·9	9	30·219	30·241	30·233	30·341	38·5	27·7
10	30·345	30·367	30·352	30·381	35·9	30·1	10	30·393	30·441	30·445	30·583	38·6	26·2
11	30·380	30·373	30·323	30·325	38·9	27·0	11	30·483	30·503	30·439	30·445	35·7	27·4
12	30·308	30·306	30·266	30·309	35·5	28·9	12	30·403	30·383	30·349	30·381	34·7	28·3
13	30·318	30·341	30·307	30·314	34·7	28·2	13	30·389	30·406	30·391	30·401	36·9	22·6
14	30·255	30·237	30·152	30·107	34·4	30·2	14	30·386	30·270	30·138	30·126	37·5	30·4
15	30·026	30·007	29·935	29·930	36·6	29·9	15	30·095	30·172	30·096	30·116	37·3	31·4
16	29·870	29·817	29·777	29·824	38·9	25·1	16	30·062	30·030	29·966	29·988	37·3	30·6
17	29·842	29·875	29·869	29·949	43·1	22·2	17	29·969	29·988	29·973	29·976	35·9	32·2
18	29·938	29·976	29·964	29·995	47·2	32·5	18	29·927	29·908	29·851	29·845	36·5	32·6
19	29·962	29·973	29·936	29·933	58·9	39·9	19	29·800	29·780	29·676	29·680	43·7	35·3
20	29·944	29·980	29·967	29·986	56·1	43·9	20	29·686	29·690	29·684	29·692	46·9	40·9
21	29·938	29·949	29·956	30·042	58·7	44·3	21	29·661	29·733	29·761	29·847	53·9	43·9
22	30·066	30·108	30·091	30·111	54·7	41·6	22	29·880	29·912	29·882	29·820	49·5	43·3
23	30·094	30·130	30·080	30·084	63·1	47·6	23	29·841	29·853	29·850	29·884	56·1	46·6
24	30·047	29·986	29·856	29·828	64·2	43·9	24	29·892	29·900	29·785	29·694	60·2	49·8
25	29·855	29·930	29·919	29·921	56·9	47·4	25	29·620	29·626	29·623	29·652	54·7	47·6
26	29·895	29·942	29·876	29·812	55·3	47·1	26	29·509	29·463	29·293	29·334	48·4	44·8
27	29·801	29·814	29·784	29·816	54·5	49·6	27	29·420	29·377	29·312	29·468	47·7	41·0
28	29·848	29·862	29·831	29·876	57·9	42·9	28	29·650	29·740	29·688	29·542	47·5	37·0
29	29·765	29·629	29·576	29·842	52·3	39·9	29	29·367	29·343	29·351	29·443	46·4	37·2
30	29·997	30·046	29·890	29·817	48·8	37·6	30	29·543	29·492	29·053	29·281	52·1	34·4
31	29·655	29·668	29·735	29·937	51·6	40·8	31	29·145	29·025	29·323	29·487	42·1	35·6

APRIL, 1886.

1	30·025	30·114	30·082	29·963	54·0	38·8	1	29·575	29·707	29·703	29·648	47·7	35·0
2	29·820	29·794	29·760	29·682	57·8	47·2	2	29·448	29·382	29·408	29·414	52·7	41·2
3	29·682	29·870	29·913	29·967	55·6	42·0	3	29·459	29·549	29·543	29·361	46·3	35·1
4	29·892	29·903	29·828	29·833	51·3	42·3	4	29·263	29·390	29·316	29·386	48·5	40·0
5	29·889	29·902	29·819	29·804	57·1	43·3	5	29·427	29·448	29·459	29·361	47·7	38·8
6	29·665	29·690	29·798	29·932	52·8	38·7	6	29·347	29·441	29·543	29·653	45·0	36·2
7	29·980	29·967	29·750	29·562	49·1	37·0	7	29·677	29·570	28·952	28·908	46 7	35·8
8	29·247	29·210	29·193	29·333	53·8	40·2	8	28·824	28·858	28·882	28·964	47·5	38·8
9	29·405	29·510	29·556	29·644	47·2	36·8	9	29·006	29·092	29·220	29·310	45·7	35·6
10	29·625	29·550	29·478	29·492	45·3	34·0	10	29·297	29·376	29·449	29·569	41·8	33·0
11	29·524	29·605	29·665	29·867	51·2	33·8	11	29·633	29·801	29·889	29·941	52·0	35·6
12	29·939	30·031	30·043	30·143	53·7	33·9	12	29·918	29·919	29·914	29·987	52·7	33·6
13	30·197	30·258	30·268	30·301	53·6	34·4	13	30·050	30·135	30·188	30·222	51·0	41·7
14	30·272	30·239	30·185	30·205	51·0	44·5	14	30·154	30·180	30·165	30·240	55·5	41 3
15	30·212	30·229	30·197	30·238	51·9	39·2	15	30·262	30·311	30·299	30·340	53·5	37·6
16	30·198	30·165	30·101	30·117	49·0	38·9	16	30·342	30·345	30·307	30·350	51·7	38·4
17	30·050	30·034	29·958	29·942	46·8	38·5	17	30·310	30·274	30·201	30·196	48·5	39·2
18	29·878	29·842	29·768	29·783	48·2	41·3	18	30·083	30·040	30·006	30·000	45·7	36·7
19	29·780	29·772	29·718	29·769	61·3	40·2	19	29·938	29·938	29·976	30·040	45·7	40·5
20	29·725	29·801	29·838	29·915	52·3	41·9	20	30·040	30·067	30·067	30·103	46·3	39·1
21	29·907	29·954	29·946	29·966	48·3	41·3	21	30·101	30·118	39·073	30·093	50·3	38·8
22	29·961	29·967	29·948	29·982	51·2	40·3	22	30·042	30·023	29·970	30·006	53·1	33·6
23	29·972	29·978	29·943	29·967	61·8	42·0	23	29·996	30·019	29·998	30·034	50·3	39·2
24	29·952	30·001	29·993	30·067	64·8	47·2	24	30·031	30·060	30·095	30·147	44·7	37·6
25	30·075	30·113	30·089	30·112	57·8	43·3	25	30·164	30·172	30·104	30·132	56·9	40·8
26	30·096	30·077	30·010	29·999	57·2	43·3	26	30·103	30·075	29·974	29·951	60·1	39·1
27	29·920	29·863	29·737	29·712	63·3	43·7	27	29·880	29·774	29·676	29·644	64·7	40·8
28	29·632	29·590	29·593	29·722	63·1	40·1	28	29·718	29·807	29·838	29·948	54·5	38·6
29	29·770	29·866	29·895	30·030	48·0	36·9	29	30·010	30·086	30·085	30·120	49·7	32·8
30	30·060	30·120	30·096	30·163	51·4	34·9	30	30·136	30·156	30·111	30·154	51·9	31·8

BAROMETER READINGS, &c.

MAY, 1886.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·183	30·220	30·207	30·317	56·9	30·9	1	30·288	30·230	30·217	30·270	52·2	40·8
2	30·338	30·363	30·336	30·379	53·1	34·2	2	30·270	30·246	30·194	30·189	56·4	35·3
3	30·372	30·384	30·349	30·375	60·9	38·2	3	30·151	30·182	30·195	30·213	53·1	44·1
4	30·393	30·405	30·387	30·424	64·9	33·7	4	30·185	30·186	30·221	30·241	55·9	47·7
5	30·447	30·447	30·371	30·371	68·1	36·9	5	30·265	30·301	30·274	30·235	51·7	47·4
6	30·345	30·318	30·239	30·232	71·3	44·0	6	30·236	30·238	30·182	30·158	63·7	49·2
7	30·196	30·169	30·093	30·081	71·9	43·4	7	30·105	30·076	30·048	30·052	63·5	44·8
8	30·047	30·023	29·979	30·001	71·9	51·1	8	30·085	30·114	30·082	30·076	55·3	44·8
9	29·999	29·983	29·903	29·896	66·2	47·4	9	30·032	30·008	29·943	29·915	44·7	42·7
10	29·831	29·788	29·770	29·797	63·2	47·6	10	29·814	29·866	29·860	29·874	44·1	40·8
11	29·792	29·812	29·789	29·781	49·9	44·9	11	29·872	29·898	29·886	29·903	48·7	39·2
12	29·699	29·614	29·458	29·334	56·1	45·2	12	29·850	29·787	29·710	29·642	45·3	38·4
13	29·143	29·065	29·133	29·200	51·7	42·9	13	29·573	29·531	29·475	29·488	51·3	36·7
14	29·230	29·313	29·449	29·581	48·6	40·0	14	29·438	29·455	29·405	29·453	51·7	40·5
15	29·649	29·726	29·778	29·909	53·2	39·8	15	29·448	29·511	29·623	29·720	54·0	40·0
16	29·935	29·876	29·815	29·848	53·8	43·6	16	29·667	29·531	29·515	29·579	53·1	36·8
17	29·828	29·793	29·763	29·742	59·0	50·2	17	29·551	29·517	29·349	29·075	54·1	42·6
18	29·718	29·727	29·738	29·869	66·0	46·6	18	29·230	29·356	29·410	29·524	56·9	46·4
19	29·904	29·954	29·922	29·907	56·8	44·8	19	29·700	29·836	29·896	29·972	57·0	44·8
20	29·840	29·841	29·877	30·022	64·6	49·8	20	30·007	30·012	29·943	29·903	50·7	37·8
21	30·059	30·108	30·119	30·164	66·2	45·9	21	29·879	29·970	30·061	30·184	58·2	43·4
22	30·125	30·106	30 096	30·095	63·0	52·9	22	30·214	30·219	30·152	30 183	64·8	37·7
23	30·045	30·070	30·018	30·008	61·7	49·1	23	30·172	30·147	30·054	30·014	57·8	42·1
24	29·936	29·863	29·763	29·767	55·2	50·9	24	29·900	29·854	29·736	29·658	54·9	44·8
25	29·735	29·662	29·590	29·579	60·8	47·8	25	29·512	29·435	29·384	29·391	54·5	42·8
26	29·572	29·595	29·502	29·545	61·0	49·8	26	29·373	29·415	29·423	29·496	53·5	41·3
27	29·385	29·414	29·501	29·497	57·8	47·2	27	29·498	29·463	29·363	29·269	52·8	37·6
28	29·547	29·681	29·703	29·763	59·0	46·3	28	29·189	29·211	29·305	29·411	46·7	42·0
29	29·793	29·838	29·835	29·902	62·1	44·2	29	29·498	29·625	29·684	29·830	56·9	44·6
30	29·922	29·963	29·954	29·990	62·8	46·0	30	29·904	29·996	30·009	30·046	52·3	44·8
31	29·971	29·989	29·928	29·916	64·3	46·0	31	30·059	30·087	30·023	30·015	56·5	43·1

JUNE, 1886.

1	29·827	29·788	29·751	29·823	70·3	53·1	1	29·961	29·929	29·881	29·853	52·7	41·2
2	29·866	29·896	29·859	29·978	69·2	49·6	2	29·850	29·944	30·003	30·096	52·9	44·3
3	29·999	30·083	30·094	30·135	55·0	48·9	3	30·114	30·135	30·083	30·107	57·7	41·2
4	30·141	30·149	30·103	30·141	61·0	42·4	4	30·108	30·117	30·086	30·108	64·3	42·3
5	30·122	30·090	29·997	29·994	60·9	40·3	5	30·078	30·047	30·011	29·977	58·7	43·7
6	29·945	29·919	29·865	29·886	68·0	43·3	6	29·930	29·912	29·860	29·840	58·1	47·6
7	29·864	29·876	29·843	29·902	68·3	44·5	7	29·830	29·866	29·848	29·880	67·7	50·7
8	29·894	29·876	29·806	29·824	67·0	46·9	8	29·807	29·844	29·800	29·772	58·1	48·8
9	29·802	29·800	29·741	29·776	71·1	51·0	9	29·732	29·722	29·680	29·698	65·3	49·8
10	29·726	29·748	29·757	29·841	63·1	53·7	10	29·688	29·716	29·710	29·760	59·7	49·0
11	29·876	29·916	29·879	29·803	65·5	51·5	11	29·734	29·709	29·656	29·581	63·0	49·3
12	29·727	29·717	29·677	29·698	67·1	51·8	12	29·480	29·476	29·488	29·554	59·1	49·8
13	29·711	29·775	29·839	29·934	62·9	49·8	13	29·610	29·680	29·732	29·812	60·5	46·2
14	29·983	30·011	29·950	29·878	62·7	46·1	14	29·797	29·678	29·496	29·624	56·3	47·4
15	29·922	30·009	30·033	30·072	63·0	49·4	15	29·630	29·716	29·770	29·826	55·7	47·0
16	30·067	30·073	30·059	30·078	61·3	47·2	16	29·869	29·951	29·992	30·037	59·5	48·0
17	30·056	30·032	30·021	30·040	59·1	46·2	17	30·040	30·060	30·058	30·104	57·9	47·6
18	30·000	29·992	29·958	29·941	51·7	48·2	18	30·066	30·044	29·978	29·988	73·1	46·8
19	29·852	29·780	29·745	29·862	67·8	49·0	19	29·955	29·937	29·907	30·015	74·9	48·8
20	29·887	29·938	29·963	30·028	60·6	49·3	20	30·045	30·067	30·005	30·029	70·7	49·6
21	30·023	30·054	30·021	29·992	57·6	46·3	21	30·023	29·997	29·957	29·901	59·9	47·3
22	29·932	29·917	29·856	29·850	65·0	52·8	22	29·823	29·752	29·661	29·647	58·7	51·2
23	29·792	29·741	29·717	29·827	65·6	50·3	23	29 521	29·483	29·507	29·627	54·3	47·8
24	29·916	29·983	29·938	29·954	70·8	46·9	24	29 707	29·725	29·675	29·635	56·7	47·0
25	29·942	29·979	29·972	30·017	71·5	50·2	25	29·665	29·747	29·787	29·837	59·5	47·7
26	30·011	30·012	29·969	30·044	73·3	51·1	26	29·877	29·933	29·969	30·047	59·4	46·4
27	30·085	30·117	30·113	30·157	70·0	53·1	27	30·099	30·121	30·093	30·095	60·8	42·3
28	30·146	30·169	30·125	30·185	73·3	54·7	28	30·076	30·089	30·107	30·153	64·6	43·9
29	30·179	30·194	30·157	30·216	75·2	50·9	29	30·172	30·214	30·201	30·246	70·2	51·2
30	30·226	30·233	30·210	30·251	70·2	52·7	30	30·239	30·234	30·206	30·205	72·6	52·1

BAROMETER READINGS, &c.

JULY, 1886.

KEW.							GLASGOW.						
	BAROMETER.				TEMPERATURE.			BAROMETER.				TEMPERATURE.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·247	30·244	30·205	30·233	70·3	48·3	1	30·179	30·162	30·116	30·123	76·7	52·4
2	30·245	30·275	30·226	30·267	75·6	50·3	2	30·148	30·172	30·185	30·214	73·5	58·9
3	30·273	30·275	30·242	30·259	81·3	52·0	3	30·212	30·228	30·215	30·232	68·7	58·6
4	30·272	30·275	30·211	30·210	83·2	60·2	4	30·199	30·163	30·153	30·211	66·1	53·6
5	30·228	30·230	30·170	30·162	77·5	58·0	5	30·206	30·178	30·122	30·053	64·9	52·7
6	30·133	30·100	29·999	30·001	81·8	53·9	6	29·936	29·900	29·912	29·921	63·6	54·4
7	29·946	29·902	29·796	29·767	79·3	57·2	7	29·871	29·837	29·795	29·779	61·1	51·8
8	29·703	29·753	29·806	29·875	66·0	56·5	8	29·766	29·776	29·794	29·888	61·7	47·8
9	29·914	29·971	30·010	30·087	65·3	49·5	9	29·958	30·005	29·984	30·030	61·6	44·7
10	30·098	30·131	30·109	30·142	67·3	48·0	10	30·043	30·065	30·029	29·983	60·9	45·2
11	30·142	30·143	30·082	30·054	70·4	48·7	11	29·859	29·794	29·753	29·783	62·5	53·2
12	29·994	29·962	29·921	29·948	66·3	52·6	12	29·757	29·753	29·735	29·762	60·1	53·4
13	29·942	29·935	29·824	29·719	70·7	50·6	13	29·724	29·712	29·568	29·332	60·5	52·6
14	29·465	29·428	29·549	29·656	66·3	53·0	14	29·093	29·206	29·315	29·405	57·9	50·6
15	29·712	29·784	29·777	29·786	66·7	51·8	15	29·478	29·525	29·555	29·554	57·6	47·3
16	29·733	29·739	29·826	29·941	69·0	50·4	16	29·517	29·623	29·743	29·812	59·1	48·2
17	29·985	29·996	29·947	29·954	67·6	53·4	17	29·824	29·847	29·811	29·780	66·9	46·4
18	29·924	29·855	29·727	29·667	77·4	56·4	18	29·699	29·662	29·626	29·532	66·6	54·2
19	29·703	29·760	29·752	29·754	70·2	56·1	19	29·479	29·538	29·517	29·621	65·5	58·8
20	29·911	30·020	30·018	30·030	72·2	54·0	20	29·688	29·798	29·862	29·882	68·1	52·0
21	29·932	29·833	29·787	29·810	81·6	58·2	21	29·856	29·744	29·622	29·565	71·7	58·8
22	29·813	29·812	29·794	29·806	69·9	59·3	22	29·494	29·392	29·342	29·378	71·7	54·6
23	29·779	29·705	29·596	29·407	64·4	58·3	23	29·403	29·443	29·421	29·402	66·1	54·6
24	29·481	29·593	29·651	29·683	67·6	56·3	24	29·383	29·422	29·460	29·493	66·1	53·2
25	29·647	29·586	29·516	29·460	72·2	51·1	25	29·498	29·514	29·494	29·520	66·2	50·0
26	29·360	29·453	29·470	29·516	66·1	54·8	26	29·490	29·492	29·532	29·628	59·6	53·6
27	29·591	29·730	29·854	29·973	59·9	52·0	27	29·688	29·769	29·828	29·926	57·7	45·7
28	30·029	30·087	30·092	30·093	63·1	46·6	28	29·953	29·978	29·968	29·964	61·1	41·2
29	30·077	30·049	29·968	29·924	66·2	52·3	29	29·922	29·886	29·804	29·738	56·7	49·2
30	29·826	29·727	29·639	29·624	71·0	56·0	30	29·681	29·655	29·596	29·612	62·9	52·2
31	29·603	29·681	29·718	29·801	69·2	53·0	31	29·604	29·608	29·596	29·612	61·7	52·8

AUGUST, 1886.

1	29·796	29·790	29·736	29·656	69·0	51·1	1	29·619	29·631	29·615	29·623	57·1	46·1
2	29·552	29·606	29·795	29·930	63·6	48·7	2	29·612	29·674	29·730	29·868	57·5	45·4
3	30·000	30·061	30·068	30·091	64·9	44·1	3	29·946	30·018	30·020	30·062	60·7	43·0
4	30·077	30·104	30·090	30·118	66·2	55·0	4	30·069	30·075	30·025	30·033	62·8	41·8
5	30·083	30·072	29·990	29·970	68·1	46·3	5	29·965	29·887	29·791	29·745	63·1	44·6
6	29·921	29·914	29·884	29·907	76·4	58·2	6	29·765	29·800	29·783	29·797	61·9	54·8
7	29·917	29·928	29·931	30·014	75·0	59·8	7	29·693	29·664	29·748	29·796	62·1	53·5
8	30·001	30·021	30·008	30·024	72·4	62·3	8	29·787	29·819	29·825	29·855	61·9	53·8
9	29·997	29·998	29·944	29·901	68·6	61·0	9	29·849	29·857	29·843	29·837	59·8	52·7
10	29·760	29·653	29·649	29·757	64·4	54·2	10	29·751	29·665	29·563	29·535	57·9	50·8
11	29·817	29·909	29·909	29·960	66·1	50·6	11	29·598	29·644	29·666	29·710	58·5	46·8
12	29·962	29·952	29·865	29·754	66·5	47·9	12	29·718	29·714	29·640	29·548	59·9	50·6
13	29·504	29·522	29·481	29·529	68·2	56·2	13	29·423	29·428	29·466	29·590	62·8	53·1
14	29·597	29·807	29·947	30·053	65·6	54·5	14	29·686	29·814	29·856	29·922	62·8	50·8
15	30·078	30·092	30·046	30·002	71·0	54·6	15	29·887	29·805	29·663	29·559	60·6	45·0
16	29·876	29·845	29·817	29·853	68·4	55·1	16	29·446	29·500	29·521	29·601	60·4	55·0
17	29·867	29·918	29·978	30·081	65·0	52·3	17	29·767	29·903	29·975	30·061	62·5	50·4
18	30·120	30·185	30·188	30·212	65·4	54·9	18	30·089	30·109	30·085	30·077	58·3	48·4
19	30·176	30·145	30·162	30·217	65·7	54·8	19	30·077	30·151	30·177	30·215	66·3	51·6
20	30·233	30·235	30·166	30·154	69·0	51·1	20	30·167	30·127	30·049	30·066	65·4	50·3
21	30·113	30·075	29·986	29·988	71·8	47·3	21	30·081	30·117	30·082	30·099	59·3	52·8
22	29·982	30·018	29·955	30·012	74·6	57·1	22	30·096	30·108	30·044	30·046	64·7	48·8
23	29·970	29·969	29·875	29·884	71·9	56·0	23	29·996	29·960	29·873	29·866	65·1	48·8
24	29·865	29·880	29·845	29·898	76·1	57·3	24	29·825	29·823	29·817	29·801	63·9	49·6
25	29·920	29·966	29·963	30·010	72·3	56·3	25	29·783	29·781	29·731	29·669	62·0	52·6
26	30·002	30·038	30·027	30·079	73·2	55·5	26	29·709	29·726	29·640	29·838	61·3	54·9
27	30·083	30·134	30·105	30·132	77·1	57·3	27	29·932	30·025	30·043	30·033	62·4	49·6
28	30·103	30·092	30·011	30·021	75·6	56·9	28	29·947	29·906	29·832	29·846	69·2	52·2
29	30·007	30·031	29·972	29·999	77·6	50·2	29	29·831	29·856	29·853	29·865	69·0	56·6
30	29·986	29·978	29·929	29·987	84·4	52·0	30	29·830	29·842	29·798	29·772	66·1	57·5
31	30·027	30·057	30·031	30·082	81·8	56·8	31	29·746	29·812	29·880	29·908	62·9	57·4

BAROMETER READINGS, &c.

SEPTEMBER, 1886.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·079	30·099	30·040	30·060	78·0	56·0	1	29·913	29·966	29·984	30·006	61·8	55·6
2	30·037	30·060	30·036	30·055	63·0	54·7	2	30·007	30·059	30·065	30·143	60·3	51·0
3	30·018	30·052	30·045	30·060	69·3	55·1	3	30·190	30·216	30·170	30·176	63·2	47·4
4	30·026	30·001	29·929	29·951	77·4	59·7	4	30·152	30·100	30·004	29·968	67·9	45·4
5	29·882	29·882	29·875	29·910	70·8	55·2	5	29·860	29·822	29·698	29·660	61·7	55·5
6	29·916	29·968	29·948	29·922	68·9	55·6	6	29·605	29·657	29·629	29·505	61·8	53·6
7	29·937	30·005	29·964	29·972	69·6	52·0	7	29·652	29·716	29·687	29·614	60·3	48·7
8	29·917	29·894	29·852	29·866	65·9	49·1	8	29·563	29·509	29·387	29·429	63·3	51·7
9	29·869	29·897	29·876	29·822	69·3	61·2	9	29·480	29·506	29·569	29·624	61·2	47·4
10	29·725	29·679	29·766	29·882	65·3	48·2	10	29·420	29·506	29·560	29·618	57·3	47·2
11	29·929	29·987	29·969	29 990	66·2	43·9	11	29·620	29·544	29·485	29·521	60·4	48·7
12	29·977	30·004	30·009	30·055	67·2	54·1	12	29·569	29·696	29·802	29·920	63·4	50·4
13	30·049	30·070	30·012	30·013	73·5	58·9	13	29·930	29·938	29·866	29·841	53·7	48·9
14	29·999	30·054	30·057	30·172	75·1	53·1	14	29·925	30·073	30·152	30·312	58·1	49·8
15	30·236	30·343	30·364	30·450	63·7	50·4	15	30·439	30·534	30·540	30·575	54·9	43·7
16	30·433	30·439	30·373	30·353	61·1	47·3	16	30·556	30·524	30·436	30·421	56·0	35·7
17	30·289	30·255	30·167	30·177	65·1	41·8	17	30·365	30·330	30·261	30·270	56·4	39·9
18	30·139	30·124	30·072	30·080	65·8	41·2	18	30·232	30·227	30·169	30·172	56·2	45·9
19	30·041	30·035	29·972	29·969	65·6	44·0	19	30·129	30·130	30·042	30·045	57·3	44·2
20	29·925	29·883	29·793	29·766	62·0	47·7	20	29·985	29·982	29·920	29·918	53·1	48·2
21	29·674	29·621	29·590	29·648	64·3	48·2	21	29·864	29·901	29·836	29·903	52·9	45·6
22	29·649	29·703	29·755	29·904	61·0	46·9	22	29·929	29·986	30·001	30·065	54·2	44·2
23	29·953	30·034	30·022	30·082	57·1	44·1	23	30·074	30·101	30·084	30·106	54·8	37·7
24	30·084	30·133	30·118	30·131	56·1	47·2	24	30·084	30·093	30·061	30·041	51·4	47·7
25	30·120	30·122	30·066	30·073	58·6	47·3	25	29·987	29·942	29·858	29·820	52·5	47·2
26	30·037	30·063	30·078	30·111	61·8	50·0	26	29·852	29·940	29·950	29·830	58·0	48·2
27	30·058	29·962	29·861	29·902	61·8	50·3	27	29·501	29·419	29·478	29·533	57·3	48·2
28	30·011	30·111	30·085	30·015	62·8	49·5	28	29·607	29·725	29·757	29·753	53·8	47·6
29	30·005	30·032	29·973	29 976	68·9	59·1	29	29·692	29·625	29·545	29·553	59·0	48·2
30	29·927	29·956	29·891	29·862	65·8	50·3	30	29·579	29·625	29·587	29·517	63·9	57·6

OCTOBER, 1886.

1	29·732	29·628	29·513	29·489	74·9	50·1	1	29·495	29·510	29·464	29·455	59·8	49·2
2	29·625	29·889	29·960	30·045	64·1	48·2	2	29·481	29·650	29·776	29·874	56·6	45·8
3	30·018	30·010	29·949	29·955	66·3	46·1	3	29·881	29·928	29·949	29·965	58·6	52·2
4	29·909	29·920	29·875	29·881	76·7	55·2	4	29·967	29·955	29·905	29·909	58·7	51·6
5	29·821	29·778	29·718	29·771	75·3	56·0	5	29·840	29·847	29·765	29·729	58·5	53·9
6	29·770	29·784	29·785	29·811	63·2	52·3	6	29·714	29·764	29·735	29·675	58·0	54·0
7	29·791	29·799	29·762	29·811	62·1	52·4	7	29·650	29·752	29·787	29·824	57·4	53·0
8	29·839	29·913	29·930	29·948	60·2	51·9	8	29·829	29·867	29·882	29·888	59·9	50·2
9	29·896	29·834	29·661	29·496	62·9	49·3	9	29·805	29·665	29·419	29·231	58·9	43·7
10	29·616	29·709	29·718	29·754	59·6	46·4	10	29·279	29·378	29·428	29·502	56·5	43·2
11	29·763	29·857	29·909	29·888	59·4	47·8	11	29·564	29·612	29·494	29·373	58·8	41·6
12	29·769	29·636	29·313	29·127	59·9	52·1	12	29·210	29·092	29·039	29·050	54·9	45·2
13	29·215	29·357	29·406	29·451	55·3	43·4	13	29·069	29·141	29·191	29·258	52·3	42·0
14	29·575	29·659	29·702	29·669	57·3	40·1	14	29·330	29·484	29·509	29·425	54·3	41·8
15	29·303	29·056	28·934	28·858	56·9	50·3	15	29·173	28·896	28·734	28·748	51·9	44·6
16	28·707	28·614	28·775	28·979	53·4	49·2	16	28·824	29·030	29·122	29·095	55·3	50·2
17	29·005	29·036	29·080	29·206	53·2	42·1	17	29·049	29·201	29·389	29·538	51·7	46·2
18	29·310	29·389	29·411	29·500	55·6	39·5	18	29·632	29·690	29·722	29·761	52·6	47·6
19	29·517	29·553	29·567	29·606	55·3	47·3	19	29·783	29·805	29·774	29·759	50·0	45·2
20	29·602	29·631	29·648	29·747	57·2	48·1	20	29·681	29·649	29·646	29·714	53·5	45·2
21	29·797	29·869	29·900	29·968	54·2	43·6	21	29·754	29·819	29·833	29·872	51·9	43·6
22	29·973	29·982	29·944	29·953	55·1	37·3	22	29·861	29·866	29·855	29·963	46·9	33·4
23	29·932	29·989	30·034	30·008	54·3	44·6	23	30·052	30·166	30·215	30·298	49·6	32·2
24	30·111	30·174	30·187	30·222	54·2	48·4	24	30·331	30·410	30·432	30·485	52·6	43·3
25	30·176	30·177	30·128	30·155	51·2	48·4	25	30·451	30·457	30·370	30·384	49·3	45·4
26	30·107	30·109	30·021	29·972	*	46·1	26	30·334	30·337	30·265	30·226	50·1	43·3
27	29·862	29·851	29·854	29·931	48·9	46·0	27	30·118	30·064	29·976	29·983	49·9	45·8
28	29·972	30·048	30·048	30·082	56·0	47·7	28	29·993	30·051	30·043	30·073	52·3	46·0
29	30·133	30·237	30·309	30·394	61·0	44·5	29	30·033	30·006	30·026	30·146	55·7	46·7
30	30·361	30·352	30·229	30·159	58·7	47·5	30	30·170	30·187	30·133	30·051	55·1	50·7
31	30·069	30·063	30·035	30·004	60·3	50·3	31	29·881	29·847	29·826	29·787	55·2	48·1

* Clock stopped.

BAROMETER READINGS, &c.

NOVEMBER, 1886.

KEW.							GLASGOW.						
	BAROMETER.				TEMPERATURE.			BAROMETER.				TEMPERATURE.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·959	30·008	30·045	30·101	58·6	48·2	1	29·692	29·686	29·755	29·696	55·0	47·4
2	30·079	30·125	30·164	30·234	56·9	42·3	2	29·756	29·926	30·005	29·965	51·9	44·7
3	30·188	30·096	29·894	29·746	53·2	33·7	3	29·703	29·434	29·332	29·462	53·0	41·9
4	29·825	29·870	29·831	29·789	53·2	39·8	4	29·473	29·510	29·464	29·490	46·3	39·9
5	29·659	29·491	29·184	29·105	*	40·7	5	29·424	29·355	29·247	29·167	43·6	38·2
6	29·030	28·928	29·004	29·218	45·2	39·9	6	29·120	29·190	29·246	29·354	45·5	41·8
7	29·390	29·540	29·589	29·716	47·4	38·1	7	29·433	29·556	29·553	29·560	43·8	35·5
8	29·731	29·748	29·620	29·521	47·6	29·7	8	29·428	29·380	29·272	29·295	45·7	36·6
9	29·351	29·254	29·191	29·283	46·4	38·0	9	29·275	29·360	29·452	29·568	45·9	42·2
10	29·300	29·321	29·364	29·458	46·4	40·3	10	29·584	29·636	29·642	29·696	46·5	41·8
11	29·478	29·491	29·483	29·547	45·9	41·1	11	29·724	29·772	29·652	29·515	48·6	38·6
12	29·522	29·502	29·422	29·401	47·1	40·9	12	29·378	29·412	29·408	29·412	44·4	36·6
13	29·428	29·465	29·458	29·508	48·3	40·5	13	29·340	29·299	29·306	29·314	47·3	38·2
14	29·479	29·536	29·570	29·594	50·1	43·2	14	29·363	29·439	29·371	29·325	48·6	32·2
15	29·571	29·542	29·451	29·477	53·6	44·5	15	29·272	29·180	29·068	29·122	51·7	46·7
16	29·467	29·580	29·645	29·691	50·4	36·9	16	29·263	29·402	29·373	29·343	47·5	36·7
17	29·569	29·314	29·524	29·758	53·4	39·0	17	29·260	29·349	29·434	29·496	44·3	37·1
18	29·829	29·944	30·056	30·143	48·6	34·4	18	29·687	29·899	29·963	29·981	44·9	37·2
19	30·181	30·213	30·211	30·256	50·8	28·9	19	29·920	29·926	29·945	30·001	53·4	38·7
20	30·276	30·330	30·314	30·350	53·8	45·5	20	30·005	30·006	29·972	30·134	54·4	46·0
21	30·317	30·335	30·349	30·408	50·3	41·3	21	30·263	30·359	30·353	30·361	48·2	34·4
22	30·423	30·464	30·451	30·501	41·0	31·0	22	30·312	30·334	30·319	30·360	54·1	34·4
23	30·512	30·569	30·561	30·630	35·1	28·1	23	30·400	30·466	30·500	30·568	49·6	44·6
24	30·648	30·698	30·671	30·644	34·2	27·6	24	30·588	30·624	30·626	30·622	51·3	48·0
25	30·595	30·590	30·524	30·523	49·6	34·3	25	30·584	30·600	30·547	30·522	51·9	44·4
26	30·490	30·486	30·444	30·442	47·0	43·0	26	30·488	30·472	30·422	30·411	44·9	32·7
27	30·434	30·450	30·424	30·434	46·0	42·4	27	30·390	30·378	30·307	30·256	45·5	41·3
28	30·396	30·372	30·263	30·126	47·0	40·0	28	30·164	30·068	29·832	29·582	47·8	45·2
29	29·908	29·790	29·711	29·664	49·8	38·9	29	29·403	29·337	29·289	29·327	47·8	40·8
30	29·621	29·635	29·633	29·778	44·3	33·8	30	29·355	29·564	29·662	29·727	42·1	33·9

* Clock stopped.

DECEMBER, 1886.

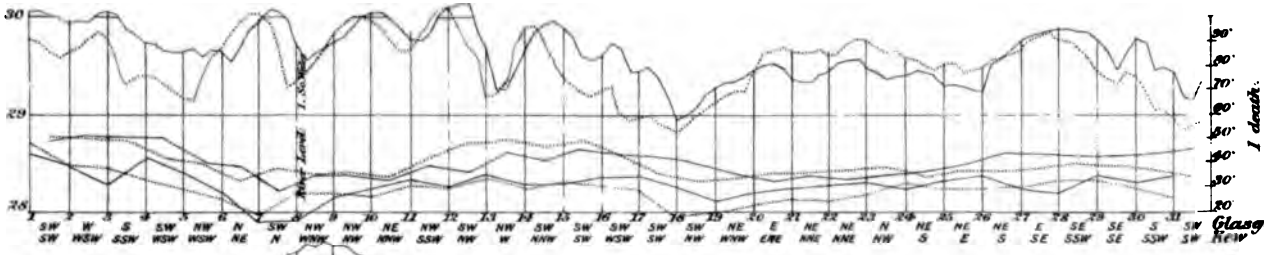
1	29·856	29·889	29·887	29·772	43·1	31·8	1	29·703	29·738	29·495	29·719	38·2	30·0
2	29·774	29·876	29·900	29·965	38·7	27·2	2	29·802	29·881	29·889	29·911	33·4	27·0
3	30·010	30·083	30·069	30·036	34·5	22·5	3	29·887	29·873	29·791	29·621	39·1	27·0
4	29·881	29·735	29·724	29·897	41·6	27·8	4	29·505	29·641	29·702	29·899	41·1	33·2
5	30·012	30·069	29·975	29·894	48·3	29·5	5	29·817	29·727	29·607	29·395	50·3	34·1
6	29·795	29·788	29·660	29·454	53·3	48·5	6	29·418	29·375	29·247	29·173	50·7	37·4
7	29·356	29·368	29·543	29·539	52·1	37·6	7	29·127	29·188	29·219	29·134	40·3	33·0
8	29·128	28·547	28·401	28·307	47·1	38·7	8	28·627	27·984	27·667	27·743	39·7	33·4
9	28·292	28·470	28·798	29·006	45·0	36·7	9	—	28·302	28·520	28·712	41·5	37·0
10	29·083	29·249	29·407	29·512	43·7	33·2	10	28·695	28·827	29·335	29·447	40·5	35·3
11	29·501	29·412	29·342	29·150	50·6	32·9	11	29·199	29·079	29·053	28·908	37·5	34·7
12	29·207	29·339	29·426	29·544	51·1	41·1	12	28·930	29·092	29·226	29·420	39·1	34·4
13	29·618	29·700	29·589	29·490	45·5	40·3	13	29·618	29·720	29·696	29·690	38·9	30·3
14	29·510	29·445	29·408	29·416	48·6	40·8	14	29·639	29·541	29·425	29·399	34·7	30·9
15	*	29·073	29·130	29·265	47·8	40·0	15	29·328	29·296	29·274	29·286	38·0	33·0
16	29·296	29·377	29·418	29·523	41·7	30·6	16	29·316	29·429	29·488	29·550	38·2	28·3
17	29·592	29·654	29·591	29·532	34·7	30·8	17	29·565	29·638	29·630	29·617	30·9	22·2
18	29·564	29·711	29·719	29·780	33·9	25·9	18	29·511	29·581	29·591	29·643	35·4	22·2
19	29·778	29·797	29·747	29·808	32·9	22·1	19	29·658	29·732	29·746	29·931	32·1	23·2
20	29·876	29·995	30·080	30·236	34·0	17·7	20	30·033	30·160	30·183	30·217	24·6	18·9
21	30·326	30·395	30·347	30·311	29·0	21·7	21	30·196	30·141	29·966	29·804	28·3	23·4
22	30·135	29·914	29·527	29·548	43·2	20·7	22	29·685	29·368	29·248	29·401	39·1	34·1
23	29·590	29·701	29·812	29·817	41·7	34·7	23	29·554	29·624	29·624	29·516	39·1	34·0
24	29·713	29·570	29·480	29·699	43·9	34·9	24	29·352	29·321	29·443	29·543	40·1	34·0
25	29·806	29·914	29·930	29·952	40·8	30·7	25	29·616	29·666	29·583	29·596	37·8	32·5
26	29·914	29·839	29·546	29·146	38·8	29·4	26	29·646	29·669	29·613	29·651	36·9	29·2
27	29·289	29·665	29·885	29·933	37·2	32·1	27	29·705	29·785	29·697	29·445	38·7	24·2
28	29·820	29·863	29·764	29·719	40·6	34·0	28	29·494	29·462	29·414	29·400	41·2	33·6
29	29·731	29·882	29·921	30·032	41·7	33·5	29	29·614	29·760	29·934	30·072	39·1	32·6
30	30·164	30·302	30·373	30·464	36·2	27·6	30	30·187	30·299	30·367	30·424	34·9	26·7
31	30·495	30·559	30·543	30·523	31·1	20·9	31	30·422	30·422	30·374	30·322	39·8	31·8

* No record.

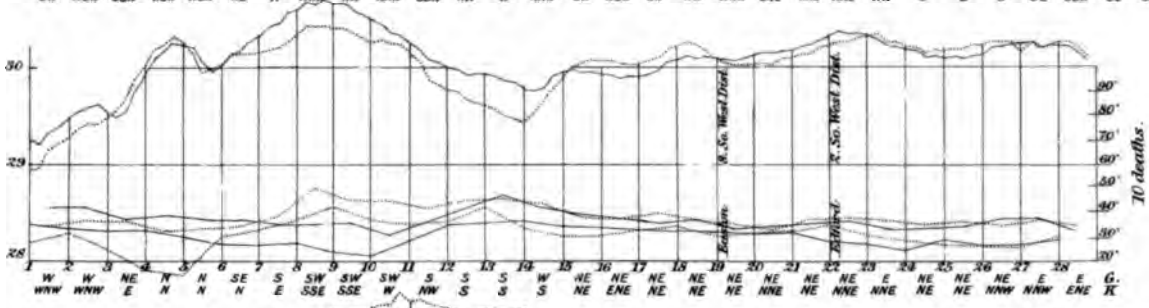
1886.

DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES of KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.

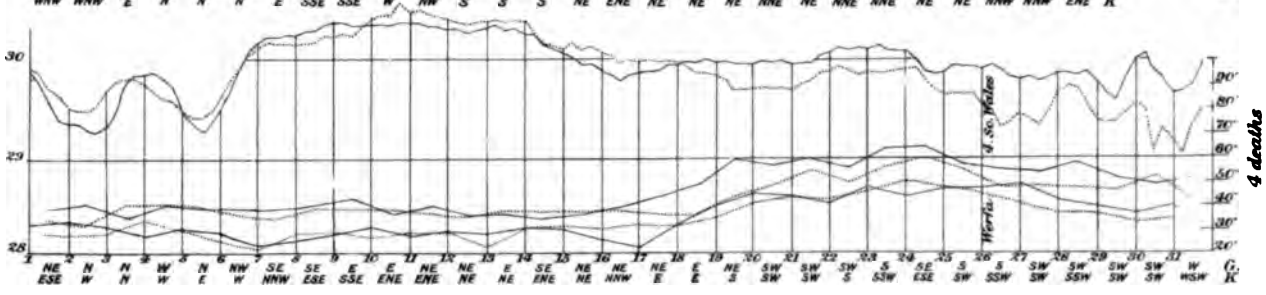
JANUARY.



FEBRUARY.



MARCH



DEATHS FROM EXPLOSIONS OF FIREDAMP DURING THE YEAR 1886.

Newcastle District	0
Durham do.	28
N. & E. Lancashire	39
W. Lanc. & No. Wales	1
Yorkshire	28
Midland	2
No. Staffordshire	0
So. Staffordshire	2
So. Western, Mon. &c.	22
So. Wales	11
E. of Scotland	1
W. of do.	0
	129

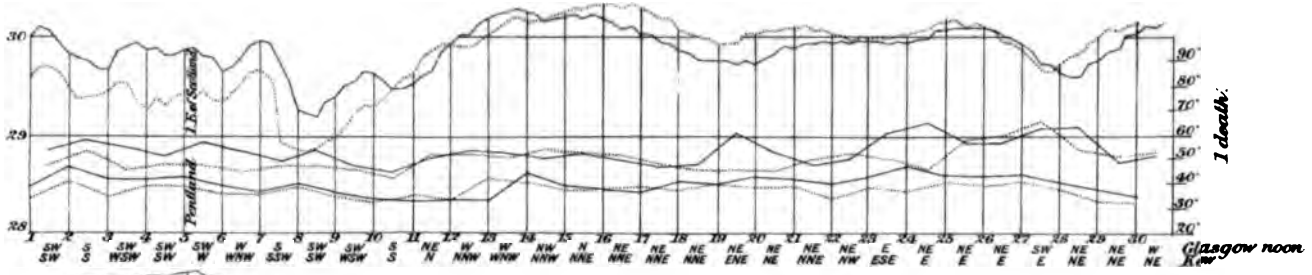
The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 a.m. & 10 p.m.
Kew lines are firm Glasgow " dotted
The figures attached to the districts shew the N° of deaths caused by the explosions.

Andrew Reid, Newcastle

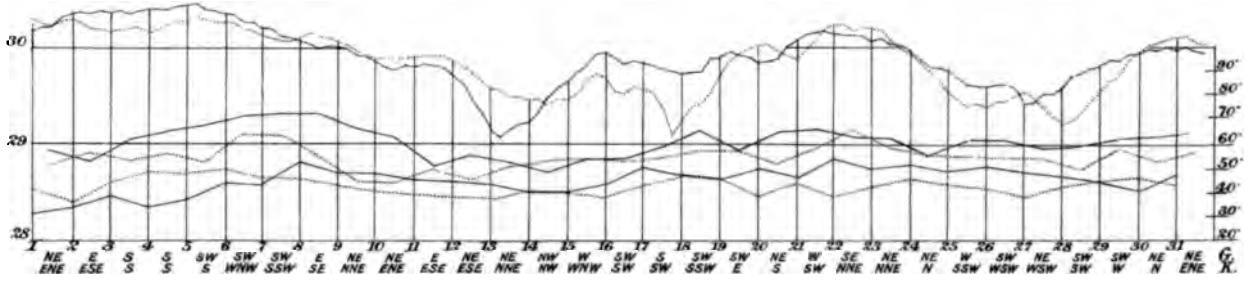
Proceedings N° E.I of M & M E. 1886-87

1886.

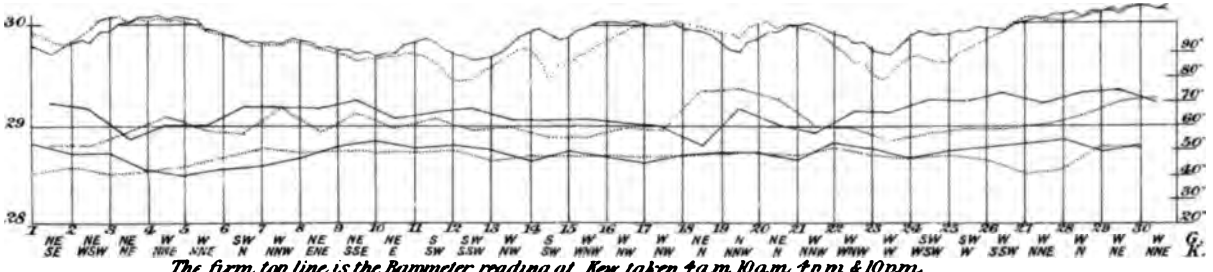
APRIL.



MAY.



JUNE.



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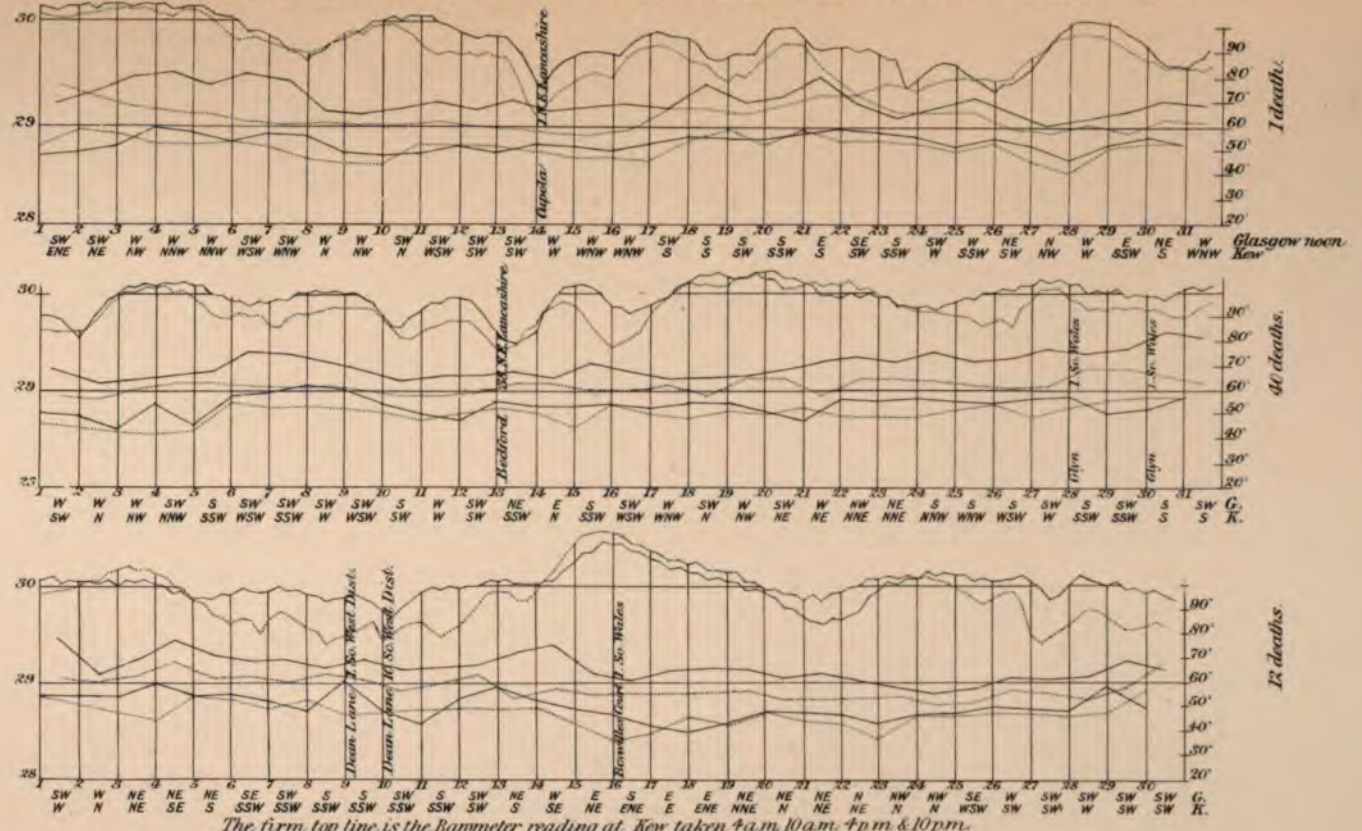
Proceedings No EI of M&ME 1886 87

Andrew Reid, Newc.a.-t.

1886.

DIACRAM SHEWING THE HEICHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES OF KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.

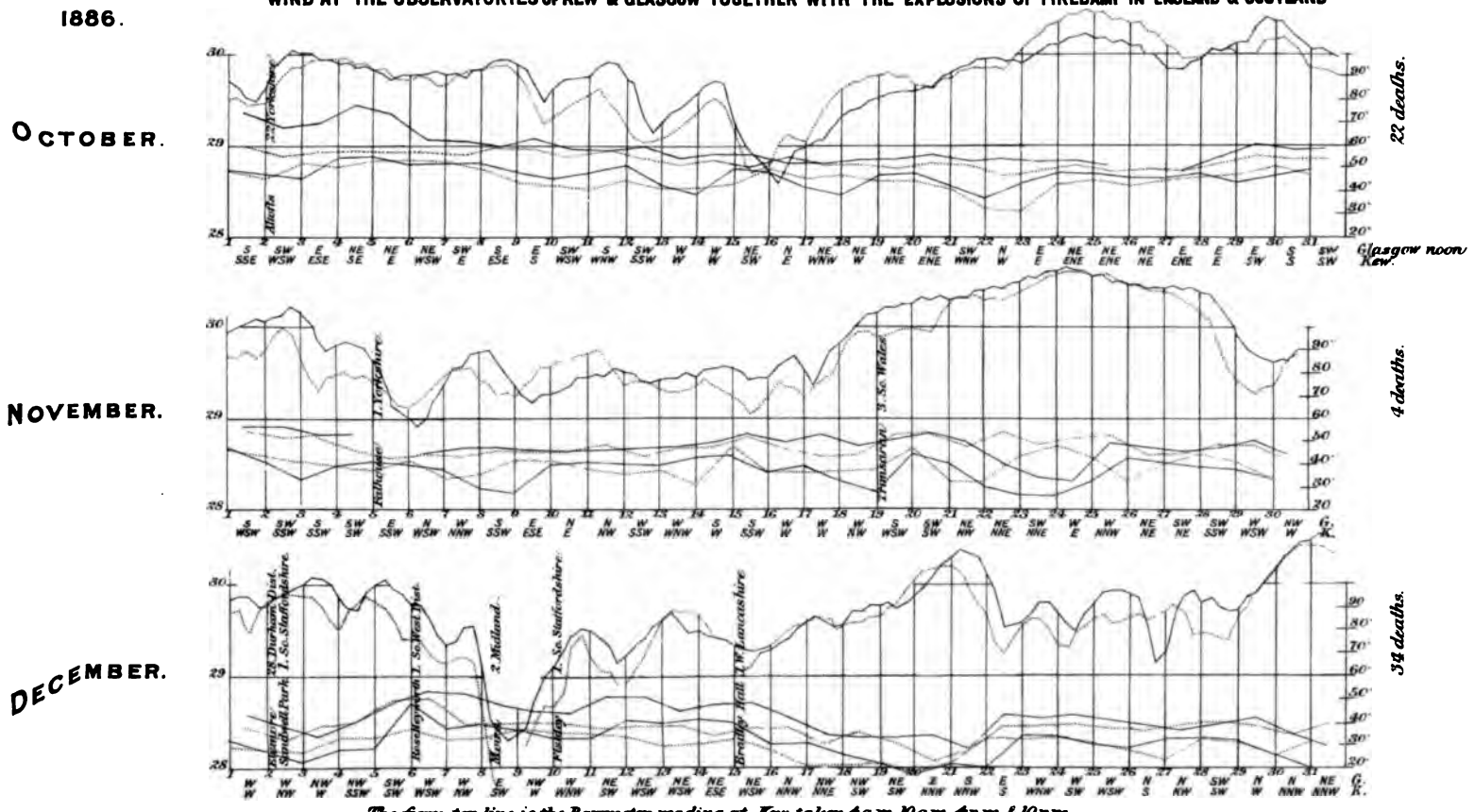

JULY.
AUGUST.
SEPTEMBER.
1 death.
40 deaths.
12 deaths.
Glasgow noon
Kew
Apedale
T.N.C. Lancashire
Bedford
Dean Lane
Dean Lane
Brownhead
1 So. Wales
Glyn
The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 a.m. & 10 p.m.
Kew lines are firm Glasgow – dotted
The figures attached to the districts shew the No of deaths caused by the explosions.

Proceedings No. E.I. of M&M.E. 1886-87

Andrew Reid, Newcastle

DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES of KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND

1886.



The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 a.m. & 10 p.m.
Kew lines are firm Glasgow - dotted
The figures attached to the districts shew the N° of deaths caused by the explosions.

Rep^t N° E.I of M. & M.E. 1886-87.

Andrew Reid, Newcastle

NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

ABSTRACTS OF FOREIGN PAPERS.

CARBONIZATION OF OAK.

Sur des morceaux de bois de chêne qui ont pris l'apparence de la houille. By — FAYOL. *Société de l'Industrie Minérale, Comptes Rendus, pp.* 78-81, *Plate X. April,* 1886.

In 1876, at the factory of Mieras (Spain), three rows of oak planks were laid down n concrete for the foundations of a steam-hammer. In 1885, on proceeding to make repairs, it was found that a portion of the wood had been metamorphosed into coal, and was adhering with such force to the cast iron, that the pickaxe was used to break it off. Specimens were taken, and were submitted to combustion and chemical analysis at the Paris School of Mines. It was found that those portions of the wood which appeared thoroughly metamorphosed had assumed the properties of perfect lignite, excepting that they contained a little more oxygen.

The author examined the planks used in connexion with two other steam-hammers, and though he observed marked changes in the wood, there was no metamorphism resembling that which has been described above. He thinks that heat and the action of water must have been the main agents of this change, and that some importance is to be attributed to the peculiar composition of the water. L. L. B.

THE SER CENTRIFUGAL FAN.

Note sur les Ventilateurs et expériences faites à Anzin sur les Ventilateurs (Système Ser) de 2 m. et de 1·4 m. de diamètre. By — FRANÇOIS. *Bulletin de la Société de l'Industrie Minérale. Sér. 2, Vol. XV., pp.* 89-108.

The Ser ventilator, 6·56 feet diameter, consists of a wheel formed of a circular plate 6·56 feet diameter, upon each side of which thirty-two curved vanes or blades are fixed. These vanes are very small; they are only ·59 foot wide and 1·38 feet long. The air, drawn in at the central inlets, is thrown out by the rotation of the vanes, into a spiral casing passing into an expanding chimney, where its velocity is reduced before passing into the atmosphere.

The two inlets are connected by means of a sheet iron gallery with the upcast pit. The fan is driven by ropes.

The following tables contain the mean results of many experiments upon two of the Ser ventilators. The results are converted from French measures as follows:— Square metres × 10·76458 = square feet; millimetres × ·03937 = inches; cubic metres per second × 2,119 = cubic feet per minute; travail en chevaux × ·9863 = British horse-power.

No. of Experiment.	Conditions of Experiments.	Revolutions per Minute.		Water-gauge.	Volume of Air.	Calculation of Results reduced to a Normal Speed of 240 Revolutions per minute.					
		Engine.	Ventilator.		Per Min.	Equivalent Orifice.	Volume of Air. Per Min.	Water-gauge. Observed.	Water-gauge. Theoretical.	Water-gauge. Manometrical Effect.	Ratio between observed Volume and Volume described by Fan.
	Ser fan, 6·56 feet diameter—			Inches.	Cub. Ft.	Sq. Ft.	Cub. Ft.	Inches.	Inches.		
1.	All orifices closed	57·12	238·78	1·811	Nil.	—	—	1·827		·60	—
						Sq. Ft.					
2.	Drawing air from mine. The stopping in fan drift has orifice of	58·80	245·78	1·944	6,530	1·83	6,370	1·854		·61	1·0
3.		58·64	245·11	2·000	11,600	3·12	11,350	1·917		·63	1·8
4.		58·02	242·52	2 008	16,420	4·41	16,250	1·964		·65	2·6
5.	Drawing air from mine and atmosphere, with orifice in stopping of 5·38	60·88	254·50	2·401	27,290	6·78	25,740	2·134		·70	4·1
6.	6·45	62·98	263·25	2·697	33,820	7·96	30,830	2·240		·74	4·9
7.	6·99	61·40	256 66	2·638	34,800	8·18	32,540	2·307		·76	5·2
8.	7·53	60·43	252·60	2·795	36,550	8·39	34,730	2·523		·83	5·5
9.	8·07	57·78	241·50	2·519	36,850	8·93	36,620	2·488	3·040	·82	5·8
10.	8·60	57·41	240·00	2·716	41,910	9·79	41,910	2·716		·89	6·6
11.	9·14	57·89	242·00	2·638	42,990	10·12	42,630	2·594		·85	6·7
12.	9·68	57·02	238·33	2·795	45,620	10·44	45,940	2·834		·93	7·3
13.	10·76	59·93	250·50	2·795	49,810	11·41	47,720	2·567		·85	7·6
14.	Drawing air from mine alone, orifice of ... 21·52	57·72	241·27	2·067	57,350	15·28	57,040	2·043		·67	9·0
15.	Doors at bank, opened a little to admit the air ...	57·84	241·77	1·896	66,320	18·41	65,830	1·866		·61	10·4
16.	Doors at bank, opened wider	55·56	232·24	1·732	68,880	20·13	71,180	1·846		·61	11·2
17.	Opened wider still	56·40	235·75	1·220	73,890	25·62	75,210	1·264		·42	11·9
18.	Doors are entirely opened	56·28	235·25	1·122	81,240	29·39	82.880	1·165		·38	13·1
						Calculation of Results reduced to a Normal Speed of 400 Revolutions per Minute.					
	Ser fan, 4·59 feet diameter—										
1.	All orifices closed	74·2	445·0	3·080	Nil.	—	—	2·488		·60	—
						Sq. Ft.					
2.	Drawing air from mine. The stopping placed in air drift has orifice of 1·13	66·2	397·0	2·579	6,790	1·61	6,840	2·618		·63	2·16
3.	2·36	67·2	403·0	2·976	10,950	2·47	10,880	2·933		·71	3·44
4.	3·66	66·4	398·6	3·366	17,430	3·66	17,490	3·390		·82	5·53
5.	4·95	66·4	398·3	3·484	24,510	5·06	24.610	3·512		·85	7·78
6.	6·24	65·4	392·6	3·228	28,070	6·02	28,000	3·350		·81	9·05
7.	9·47	61·3	368·0	2·445	31,740	7·75	34,500	2·890	4·134	·70	10·91
8.	13·13	61·2	367·0	2·303	33,630	8·50	36,650	2·736		·66	11·59
9.	The stopping is removed	60·5	363·0	2·110	33,820	8·93	37,270	2·559		·62	11·79
10.	Door is slightly opened to admit the air	57·9	347·6	1·819	35,940	10·22	41,360	2·409		·58	13·08
11.	Door opened wider	53·7	322·5	1·224	41,150	14·21	51,040	1·882		·46	16·14
12.	Door opened wider still	49·8	299·0	·657	43,660	20·56	58.400	1·177		·28	18·47
13.	Door is entirely opened	48·0	288·3	·323	43.660	29·28	60,570	·626		·15	19·16

The Guibal fan has the maximum manometric efficiency of ·70, the Schiele varies from ·32 to ·46, and the Winter, Pelzer, and other German fans, rarely exceed ·30. It will be seen from the tables of experiments upon the Ser fan that the 6·56 feet fan yields ·93 and the 4·59 feet fan yields ·85 of manometrical efficiency.

The following table shows the mechanical efficiency of this fan:—

Equivalent Orifice.	Revolutions of Engine per Minute.	Total Indicated Horse-Power.	Horse-Power wasted by the Engine.	Horse-Power applied to the Fan.	Horse-Power in the Air.	Useful Effect.	
						Calculated from Indicated Horse-Power.	Calculated from Power applied to Fan.
Sq. Ft.						Per Cent.	Per Cent.
11·41	60	47·45	11·83	35·62	21·94	46	61
17·00	61	69·88	13·41	56·47	32·68	47	58

M. W. B.

TIN MINING IN PERAK (PENINSULA OF MALACCA).

Note sur la Géologie et sur l'Industrie Minière du Royaume de Perak et des pays voisins (presqu'ile de Malacca). By J. De Morgan. *Annales des Mines, Sér.* 8, *Vol. IX., pp.* 368 to 444, *Plates VIII., IX., X.*

I.—Geology.

The geology of the Malay peninsula may be provisionally arranged as follows:—

Azoic ...	...Gneiss.
	Slates.
Silurian...	...Quartzites.
	Schists (*a*) coarse, brown and black.
	(*b*) finer, reddish brown.
	(*c*) fine, blue and green.
Upper Silurian or Devonian	Limestones.
Post Pliocene	....Stanniferous alluviums.
Recent ...	...*Bakaos* (alluvium and soil).

The series of eruptive rocks is very complex, and consists of coarse granites, elvan, pegmatite, leptynite, diorite, porphyry, quartz, kaolin, or decomposed granite, calcite, etc.

Tin is found in elvan at Campong Monilé, and, from comparison of minerals at this mine with those from alluvial deposits, it is probable that tin rock occurs in the mountains of Gounong Krbou and other hills, from which the alluviums have descended. In the mines of Tchandériang and Kampar large pieces of tin ore are frequently found, with adherent quartoze matrix. Gold bearing veins will also probably exist, although none have been discovered, the natives being content to work the placer mines of Batang Padang, etc. Silver and lead are found associated in galena at Patani, but have not been discovered in Perak.

Alluvial deposits of indefinite age fill all the valleys of Perak, but as they contain stone instruments the formation is almost within historic time. They consist at the bottom of an argillaceous bed (*kong*) covering the silurian rocks; this is next overlaid by beds of sand and clay, containing tin ore in elongated pieces, whose dimensions vary according to the mining deposits. The thickness of these deposits is about 45 feet at Pappan, at Lahat from 15 to 35 feet, at Klian Lalang from 12 to 15 feet, etc.

The rich alluviums are not continuous, but form lenticular deposits, which are sometimes very large and very numerous, and in other cases are very far apart.

The proportion of tin ore varies with the localities, but the maximum does not exceed 45 pounds per ton of earth. The richness is very irregular, samples from the

same deposit, less than 10 feet apart, may vary from 2 per cent. to less than ·1 per cent. Deposits containing ·6 to 1 per cent. are not rare, and in this condition are workable to profit when the depth is not too great.

An average analysis of the prepared tin ore is:—

Tin	65	Tin ore.
Oxygen	17	
Silica	12	Impurities due to imperfect washing.
Alumina	4	
Iron	traces.	
Water	2	

consequently the tin contains no impurities which would reduce its quality or value.

II.—Industrial.

Tin Mines.—Although worked for many centuries the tin mines are far from being exhausted. The first workings were made near Larout, but to-day, it is found throughout the valley of the river Kinta. The richest deposits are found on the east side of the valley of the river Kinta, especially at Gôping, Tchandériang, and Kampar, which are also the most regular in the nature of the deposits.

The explorations require to be carefully conducted, as the composition of the alluvium is most variable, and borings alone are not a sufficient test of the value of the deposits. A boring is frequently situated between two adjacent rich deposits. Borings only yield comparative results, their greatest utility being in testing the thickness and depths of the deposits.

III.—Modes of Working.

There are two systems of working practised, the native method, used for many centuries by the Malays and Siamese, and the Chinese system only recently introduced.

Malay System.—The Malays employ two different methods according to the position of the deposits. If the beds are on the side of a hill a large cutting is made into the deposit, and the sterile portions are thrown into the valley.

When the deposit is in the valley it is worked by small oblong pits. Three of the sides are sustained by bark (as backing) and vertical piles, the fourth side is worked in steps. The water is drained by buckets suspended to long levers, with a counterbalance, which are used as often as required during the day. The sterile beds are deposited by the side of the pits, and require removal on extending the area of the workings.

The sluices are placed in the ditches when the mine affords sufficient water. When the mine is almost dry the sluice is placed in some adjacent stream, but many mines of moderate richness are abandoned, on account of the cost of transport to the sluice being too great. When the mines are very rich, water is brought from higher levels by means of ditches, and carried in wooden pipes across the valleys. In general, the rich earth is placed in the ditch near the mine, and washed the next day by the water removed from the pit before work is resumed in the morning. If the water is insufficient, the mineral earth is collected in heaps, and washed in the rainy season.

The washing is made in one operation at some Malay mines, but it generally consists of cleaning and washing. The cleaning is practised in an open ditch, in which the earth is agitated with water until the whole of the mud is carried away, and the water runs away quite bright. The mineral is then pushed with scoops or by the feet into the sluice. By this method the mineral is concentrated to 20 or 30 per cent. of metal.

The sluice is made of a hollowed tree or piece of bark, and washing is effected by pushing the mineral to the upper part of the box. The Malays judge the completion of the washing by the colour of the sand, and rarely obtain concentrates with more than 55 to 65 per cent. of metal. The sluices are usually about 5 feet long and about 1 foot wide, whose inclination varies according to the fineness of the tin stone. In many mines the batea or cradle is very expertly used by the Malays.

The same workmen perform all the necessary operations about the mines and furnaces, and the cost is obtained by considering the number of men employed. For six mines in the Kinta district, the production per man employed per thirty days was:—

	1.	2.	3.	4.	5.	6.
Tin in pounds	57·8	66·1	97·8	85·4	129·5	137·8
Value of tin	41s. 6d.	47s. 6d.	69s. 6d.	61s. 0d.	92s. 6d.	99s. 0d.
Wages or cost of mining..	31s. 9d.	31s. 9d.	31s. 9d.	31s. 9d.	31s. 9d.	31s. 9d.
Cost of smelting	3s. 9d.	3s. 9d.	5s. 6d.	4s. 9d.	7s. 6d.	7s. 9d.
Profits	6s. 0d.	12s. 0d.	32s. 3d.	24s. 6d.	53s. 3d.	59s. 6d.

Chinese System.—Under this system workings are commenced at the lowest point of the area; a deep cutting is opened, whose sides are turned against the deposits to be worked. When this trench reaches the kong, or bottom of the deposit, another slice is taken off, and so on. The sterile matter is placed into the first trench. All material is carried on men's backs. Drainage is effected by norias, driven by water wheels; but steam pumps of eight or ten horse-power have been introduced with advantage. Work is carried on in a regular manner, each man adhering to his own class of labour. Under these conditions a mine of ordinary richness will produce about 5,760 pounds of tin per month at a cost of from £27 to £45, and yield a profit of from £60 to £40 per ton of tin, taxes only excepted.

IV.—Metallurgy.

There are four kinds of metallurgical furnaces employed; they are the Malay, Siamese, Chinese earth, and Chinese brick furnaces. These furnaces are all of the same system, differing only in size and solidity of construction. They consist of an internal cavity, with a hole at the bottom, and a basin for the fused scoria and tin, and the blast is given at the back and downwards by a piston blower; they are fed with charcoal, and work continuously.

The following table shows the relative dimensions, cost of working, etc.:—

Description of Furnace.	Malay.	Siamese.	Chinese Earth.	Chinese Brick.
Height	4 ft.	5 ft.	5 ft.	6 ft.
Width	3½ „	2¼ „	4 „	7½ „
Life, or duration	30 days	60 days	60 days	5 years.
No. of workmen employed per day	6	8	6	9
Weight of tin produced per day ...	550 lbs.	1,320 lbs.	2,200 lbs.	4,850 lbs.
„ charcoal used per day...	490 „	1,220 „	2,100 „	4,400 „
Weight of charcoal used per ton of tin produced ...	2,000 „	2,080 „	2,130 „	2,040 „
Weight of scoria per ton of tin produced	106 „	117 „	112 „	121 „
Weight of tin in scoria per day ...	26 „	70 „	112 „	250 „
Cost of constructing furnace ...	15s. 0d.	97s. 6d.	131s. 0d.	322s. 6d.
Cost of labour per ton of tin ...	45s. 0d.	24s. 9d.	11s. 3d.	7s. 9d.
„ food „ „ ...	11s. 6d.	8s. 3d.	3s. 9d.	2s. 3d.
„ charcoal „ „ ...	81s. 9d.	82s. 9d.	85s. 6d.	82s. 9d.
„ sundries „ „ ...	5s. 3d.	5s. 3d.	8s. 9d.	8s. 9d.
„ materials „ „ ...	2s. 3d.	3s. 3d.	2s. 6d.	1s. 6d.
„ inspection „ „ ...	3s. 9d.	3s. 9d.	3s. 9d.	3s. 9d.
Total cost ...	149s. 6d.	128s. 0d.	115s. 6d.	106s. 9d.

The tin ore usually sells for about £50 per ton, and if the cost of smelting, 150s., and export duty, 180s., is added, the cost will be £66 10s. per ton, and the smelter will realize from £12 to £20 per ton profit, according to the price of tin.

Legislation.—The tin grounds belong to the Government. The concessions are granted to natives and foreigners, and vary in area from 200 acres to 1,000 acres in special cases. There are two taxes, the royalty of about 42s. per ton, and the export duty, which varies from time to time. It is usually about £9 or £10 per cent. *ad valorem.*

Statistics.—The production and value of tin is as follows:—

Year.	Districts on Coast. Tons.	Perak River District. Tons.	Total. Tons.	Value. £
1876	1,783	271	2,054	178,850
1877	2,511	547	3,058	266,250
1878	2,895	739	3,634	316,850
1879	3,478	848	4,326	376,700
1880	4,440	1,067	5,507	479,600
1881	5,070	1,270	6,340	591,650
1882	6,336	1,468	8,804	766,500
1883	7,944	2,008	9,952	862,250
1884	8,014	2,696	10,710	932,500

M. W. B.

BALANCE PUMPS FOR SELF-ACTING INCLINED PLANES.

Balance Pumps for Gravity Planes. *By* E. Gybbon Spillsbury, M.E. *The Engineering and Mining Journal (New York). Vol. XLII., p.* 314.

In the working of self-acting inclined planes, in highly inclined seams, there is a very considerable surplus of power absorbed by a more or less powerful arrangement of brakes.

An ingenious system for the utilization of this power has been in successful operation for eighteen months at the Rhein Preussen Colliery. At this colliery, all the coal is drawn from the 1,020 feet level, and all the coal mined above the 810 feet level is run down to the lower level by self-acting inclined planes. On an average, one tub, carrying 1,100 lbs. = 9·84 cwts. of coal, passes over this plane per minute. The power produced by the descending tubs will be $\frac{210 \times 1100}{33000}$ = 7·0 horse-power.

A portion of this power is utilized by placing upon the drum shaft a crank disc which drives a double plunger pump. This pump takes the water from the 1,020 feet level and forces it through a system of pipes (2·52 inches diameter) to accumulating tanks on the surface, a height of 820 feet. The diameter of the drum is 3·12 feet, or 9·80 feet circumference, therefore, the drum makes 210 ÷ 9·80 = 21·5 revolutions by the descent of each tub. The crank disc is 1·31 feet diameter, and drives a double plunger pump, 2·36 inches diameter and 15·74 inches stroke. Each car raises $\frac{2 \times 15{\cdot}74 \times 21{\cdot}5 \times 2{\cdot}36^2 \times {\cdot}7854}{277{\cdot}123}$ = 1068 gallons per minute, and the power utilized is

$\frac{1068 \times 10 \times 820}{33000}$ = 2·65 horse-power.

There is, accordingly, a constant pressure from the accumulator tanks of 800 feet of water, which is drawn from the pipes, for running coal-cutting machines, small hauling engines, and for the ventilation of single drifts by Körting's spray-blowers.

The inclined planes are all laid with double way, and in practice it is found that a greater speed is permissible upon them since the introduction of the balance pumps, than could be maintained under the old system of brakes. M. W. B.

COPPER OF EL BOLEO.

Note sur le gîte de cuivre du Boléo (Basse-Californie Mexicaine). *By* Ed. Fuchs. *Bulletin de la Société Géologique de France. Sér.* 3, *Vol. XIV., pp.* 79-92, *Plate VI. (Map). February,* 1886.

The district of El Boleo is situated on the Western coast of the Gulf of California, opposite the harbour of Guaymas. It is, roughly, a plateau of five miles by three, bounded by the sea to the N.E., and by a wide fault, parallel to the coast, to the S.W. This plateau dips gradually from 300 metres to 70 (1,000 to 225 feet) towards the sea. A few isolated peaks surmount it here and there, while on the N. it merges into the slopes of Las Tres Virgines and Santa Maria, and the lower spurs of the easternmost hill chain of Lower California.

Four ravines, perpendicular to the coast-line, cut the district and show clearly its geological structure, which, from the surface downwards, is as follows: —

Tuff and conglomerates, about 40 metres (131 feet).

First copper bed, average thickness 1 metre (3·28 feet).

Conglomerates and tuff, between 45 and 50 metres (148 to 164 feet).

Second copper bed, thickness varying from 80 centimetres to 2·30 metres (1½ to 7½ feet).

Conglomerates and tuff, between 50 and 55 metres (164 to 170 feet).

Third copper bed, thickness varying from 60 centimetres to 3 metres (2 to 10 feet).

Conglomerates and tuff.

A few igneous rocks (very slightly acidic trachytes) rise up beside the above-named sedimentary rocks, forming a double range parallel to the coast, of which the westernmost branch marks in that direction the boundary of the copper district. An immense sheet of basaltic lava tops the whole, covering the peaks and invading even the plateaux formed by the stratified rocks.

After examining in some detail the composition of the tuff beds, the report proceeds to specify the appearance and composition of the ore. The metal is found in little spots or veins, and sometimes in oolitic balls, irregularly scattered over the matrix; but a marked concentration is noticeable at the base of the bed, where the ore forms a compact layer varying from 6 to 10 inches. As regards its composition, it appears generally as cupric oxide, associated with carbonates and sometimes hydrosilicates of copper. The matrix is a clayey tuff of a light grey colour.

Little is said of the first bed, except that it appears to be the poorest of the three. The second is remarkable for the large proportion of silica which it contains, and in it are found almost exclusively the oolitic balls or *boleos* already mentioned; they contain 35 to 40 per cent. of copper in some cases. It is easy to separate them from the matrix, and to obtain an ore of an average yield of 25 to 30 per cent.

In the third bed appear yellow clays, yielding 10 to 15 per cent. of the metal; compounds of copper and manganese, 32 to 43 per cent.; black copper oxide, as much as 60 per cent. Two sulphuretted ores are found where the lode is beneath the water level: some engineers have regarded this fact as pointing to a gradual substitution, which would finally leave only sulphuretted ores in the lode, but M. Fuchs does not subscribe to that conclusion.

A table is given of analyses, made at the Paris School of Mines, of 180 specimens taken from the different workings. The general average of metallic copper is 15 per cent. None of the precious metals have been found in the ore.

The conglomerates and eruptive rocks are then briefly described, and the author enters at some length into the geological history of the district. L. L. B.

THE GEOLOGY OF EASTERN SIBERIA.

Notes géologiques sur la Sibérie orientale, d'après les observations faites par M. Martin, dans son voyage d'exploration du lac Baïkal, du bassin du fleuve Amour, et du lac Khanka. *By* CH. VELAIN. *Bulletin de la Société Géologique de France. Sér.* 3, *Vol. XIV., pp.* 132-166. *Map and sections in the text. March,* 1886.

Lake Baikal and the Salenga.—Cliffs of crystalline schist, interrupted by massive wedges of granite and granulite, border the lake. Micaceous and hornblendic gneiss are found at Irkutsk and on the western shores of Baikal; in the hornblendic rock there is a large proportion of sphene.

Stavonoï.—Granulite, containing tourmaline, is the chief constituent rock of this mountain range. Great blocks of porphyroid granite form the summits of some of the mountains.

Amur Basin.—Fragmentary clayey red sandstone on the eastern edge of the Stavonoï. In the neighbourhood of Wertchinsk, coal formation with workable seams. Gneiss, augite, hornblendic granite, and granulite appear in the district between Strelka and Khingan. Euphotide especially rich in titanic iron is mentioned.

Ussuri and Lake Khanka.—Mainly gneiss with micaschist.

An extremely detailed description of the specimens brought to Paris by M. Martin, with microscopic analysis, follows. L. L. B.

SPONTANEOUS COMBUSTION OF PYRITES.

Incendies dans les mines de pyrites. *By* J. B. DURAND, — DRILLON, — PÉRISSEL, *and* —FUMAT. *Société de l'Industrie Minérale, Comptes Rendus, pp.* 102-106, 116-117, 121-123, 140-141. *May, June, July, and August,* 1886.

This series of papers commences with an account of a fire which occurred in the mines of Kef-Oum-Theboul, and which was attributed by J. B. Durand to the oxidation by the air of masses of pyrites. But this theory was contradicted by the manager of the mines, who explained that the fire was due to the upsetting of a lamp over a heap of faggots. The engineer of the mines of Sain-Bel said that there the temperature never exceeded 38 degs. C., and that the oxidation of the pyrites, even when heaped up in the open air, was exceedingly slow. It seems, however, that the engineers of La Grand' Combe, and of Soulier and St. Félix, near Alais, agree with Durand, but stress is laid on the presence, in the last-mentioned place, of marls which are mixed up with the pyrites and are thought to be the main cause of the gradual heating and combustion which ensues. L. L. B.

PEBBLES IN THE COAL OF CENTRAL FRANCE.

Galets des terrains houillers du Plateau Central. *By* — FAYOL. *Société de l'Industrie Minérale, Comptes Rendus, pp.* 136-138, *Plate XXI. August,* 1886.

After laying down the principle that the process of formation of coal deposits was similar to that of river deltas at the present day, the author proceeds to sketch briefly the history of the coal deposits of the Plateau Central, basing his conclusions on his study of the pebbles which are found there. L. L. B.

THE GEOLOGY OF SOUTH ABYSSINIA.

Observations géologiques sur les Pays Danakils, Somalis, le Royaume du Choa et les Pays Gallas. *By* M. AUBRY. *Bulletin de la Société Géologique de France. Sér.* 3, *Vol. XIV., pp.* 201-241, *Plates XI. and XII., with sections in the text. April,* 1886.

The report commences with a brief summary of the physical features of the French colony of Obokh. The territory consists roughly of a plateau, 15 miles in breadth, rising in two successive terraces from cliffs of coral formation, and bounded northwards and westwards by volcanic mountain ranges. A soft limestone, impregnated with sodium chloride, gypsum, and magnesian salts, is the chief constituent rock; it contains fossils identical with species yet found living in the Indian Ocean. Several wells have been dug in the colony; and a hot spring, highly charged with sulphuretted hydrogen and other compounds of sulphur, bursts out near the western extremity of the bay of Obokh.

The mountains which mark the limits of the French possessions are formed principally of trachytic and basaltic rocks, similar to those of Aden. A kind of obsidian, which has been mistaken, both by natives and Europeans, for coal, is noteworthy; it yields a whitish glass when fused. Journeying westwards from Tadjurah, the Assal Lake is reached. Half of its area of 60 kilometres is taken up by deposits of common salt and gypsum, and the latter mineral, in a bed 50 feet thick, forms a ring round the entire lake. Between Lake Assal and the Abyssinian Mountains intervene a volcanic range and a vast desert (800 metres above the sea—tufa, with numerous hot springs).

From Ankober southwards to Kaffa, the country is a plateau (altitude from 2 to 3,000 metres) of trap formation, but sandstones are found over a stretch of 50 miles in the southernmost portion. In the region of the river Hawash, the high plateau is succeeded by a lower table-land, covered with tufa and trachytic ash giving rise to calcareous rocks. These latter are worked for lime, but with poor success, as they contain a large proportion of alkaline carbonates. Numerous extinct craters are scattered over the whole district, and two geysers spring up near the source of the Hawash.

The valleys of the Zega Ouedem and the Jamma are similarly of trap rock formation, interspersed with sandstones, calcareous rocks, and marls. Gneiss, granite, micaschist, etc., are found in the Somali country, from whence also specimens of galena and auriferous granite have been brought.

En resumé, the geological constitution of South Abyssinia is very similar to that of North Abyssinia, as described by Blanford in 1868.

The report concludes with a description of the principal fossils found by M. Aubry.

L. L. B.

PLANTS OF THE COAL FORMATION.

Botanique Fossile.—Sur quelques Cycadées houillères. *By* B. RENAULT *and* R. ZEILLER. *Société de l'Industrie Minérale. Comptes Rendus, pp.* 96-98. *May,* 1886.

A detailed description is given of specimens of Noeggerathia, Pterophyllum, and Zamites. The specimens of Zamites were brought from Commentry, and were remarkable from the fact that, hitherto, the genus had only been fouud in Secondary and Tertiary formations.

L. L. B.

THE FLORA OF LA GRAND' COMBE.

Note sur la flore et sur le niveau relatif des couches houillères de la Grand' Combe (Gard). *By* R. ZEILLER. *Bulletin de la Société Géologique de France. Sér.* 3, *Vol. XIII., pp.* 131-148, *Plates VIII. and XI. March-April*, 1885.

The object of the report is to contribute some definite data for establishing the relative antiquity of the systems of la Montagne Ste. Barbe, Champelauson, and Trescol. The author describes the position of the strata and the thickness of the seams, and then reviews briefly the opinions expressed by engineers and scientists as to their geological chronology. This is followed by a detailed account of the plant remains found in the coal. The author comes to the conclusion that the order of antiquity of the beds is as follows:—1. Montagne Ste. Barbe; 2, Trescol; 3, Champelauson, the oldest being numbered 1. L. L. B.

THE COAL FORMATIONS OF THE ALLIER.

Age des couches argilo-silicieuses qui recouvrent une partie des terrains houillers de Commentry et de Montvicq, et que l'on retrouve sur beaucoup d'autres points du département de l'Allier. *By* — FAYOL. *Société de l'Industrie Minérale, Comptes Rendus, pp.* 135-136. *August*, 1886.

Overlying a portion of the coal formations of Commentry and Montvicq are certain very nearly horizontal strata, 30 to 60 feet thick, composed of sandstones and clays, and which, in Boulanger's Geological Map of the Allier (1845), are marked as belonging to the Tertiary period.

The coloration of the rocks resembles that of kaolin, but, in the upper portion, it becomes in some places yellow or brick red. Some of the sandstones have a porphyritic appearance, and in the mass fragments of chalcedony are found. The discordance of stratification between these almost horizontal beds and the coal, which at points dips 50 degs., is very marked. It was thought until lately that no fossils were to be found in these so-called Tertiary formations, but the author discovered at Montvicq a quantity of plant remains of Carboniferous or Permian age. The fossils are not black, the carbon having disappeared under the action, it is supposed, of hot springs—in some cases a yellowish indistinct coating replaces the carbon. Taking into account the mineralogical composition of the deposits, in which everywhere the action of ferruginous and siliceous springs is traceable, the author believes that they belong to the Permian period. L. L. B.

THE GEOLOGY OF ASSINEE.

Note sur la Géologie de la possession française d'Assinie, côte occidentale d'Afrique. *By* — CHAPER. *Bulletin de la Société Géologique de France. Sér.* 3, *Vol. XIV., pp.* 105-112, *Map in the text. February*, 1886.

After some preliminary remarks on the physical aspect and structure of the West Coast of Africa from Cape Palmas to the Bay of Benin, the author proceeds to summarise the result of observations made in the French colony of Assinee.

Generally, the soil is either sand or clay. The sand is quartz, and is everywhere auriferous, but the proportion of the precious metal is so small that it could hardly be worked with advantage by Europeans. The clay is very greasy and plastic, in some cases slightly micaceous; on the slopes and plateaux it becomes ferruginous, and gradually merges into compact layers of limonite. Beneath the clays decomposed

micaschist and quartz veins were found. M. Chaper was at one point only able to find masses of crystalline rock, namely, at the Falls of Aboisso. Siliceous schist, containing hornblende, epidote, and small grains of milky quartz, there forms a thick mass, squeezed in the fold of another rock, which latter is a granulite, with green mica and a large proportion of epidote.

Geological observations are extremely difficult at Assinee, on account of the exuberant vegetation of the country, but the author was enabled to refer the general constitution of the upper rocks to the glacial period.

The negroes wash the clays for gold, but, as with the sand, the proportion is too small to repay an outlay of European capital, for there is at present no mechanical means of extracting very finely divided gold from compact clay within a reasonable time. L. L. B.

PETROLEUM IN INDIA AND BURMAH.

Note on the occurrence of Petroleum in India. By H. B. MEDLICOTT. *Records of the Geological Survey of India, Vol. XIX.* (1886), *pp.* 185–210, *with folding Plate of Sections.*

After discussing the nature and origin of petroleum, and describing the mode of its occurrence in Pennsylvania, at Baku, in California, and in Galicia, Roumania, and Transylvania, the author gives an account of the mineral oil localities known up to the present time in India and the adjoining countries.

1.—*The Punjab.*—All the Indian petroleum is found in Secondary and Tertiary rocks. Sixteen oil-producing spots are known in and about the Rawalpindi district, eleven gallons per day for six months from a 75 feet borehole being the greatest yield recorded. The oil-bearing beds here belong to the Upper and Lower Nummulitic series.

2.—*Khátan.*—The Khátan oil-region is in the Mari hills of Baluchistan, and a full report upon it by Mr. R. A. Townsend is appended to Mr. Medlicott's paper. The oil-beds seems to be here also of Eocene age, and their exploration by means of borings has been most successful. Oil was obtained in large quantities at depths of 28, 62, 92, 115, 125, 133, and 374 feet.

3.—*Assam.*—Oil has long been known to occur in connexion with the coal-beds of Upper Assam. Borings less than 200 feet deep and yielding, in some cases, 3,500 gallons in 35 hours, several years ago proved an abundant supply. The rocks containing the oil are probably of Middle Tertiary age. Difficulties of transport alone prevent these springs from being largely and profitably worked.

4.—*Arakan.*—As much as 40,000 gallons of oil a year has for a long time been extracted by natives and exported from Kyoukpyu, in the neighbourhood of the well-known mud-volcanoes. A large supply of petroleum is undoubtedly present, but having been worked by European companies since 1877, by improper means, it has not yet proved a commercial success. In 1883 the total amount of crude oil pumped from ten wells did not exceed 234,000 gallons.

5.—*Burmah.*—The Burmese petroleum is the well-known "Rangoon oil." It almost all comes from Upper Burmah, and from the neighbourhood of the Yenanchaung, on the east side of Irrawadi, about 60 miles above Thayetmyo. The oil-bearing beds are Lower or Middle Tertiary. In 1883–84 about one million gallons of crude oil came to Rangoon, but it is extracted in the rudest manner, and the supply is capable of almost indefinite extension. In conclusion the author says:—"It is, I think, a safe prophecy that the oil-measures of Eastern India may be supplying half the world with light within a measurable time when the American oil-pools have run dry." G. A. L.

MINING IN NEW CALEDONIA.

L'Industrie Minérale en Nouvelle Calédonie. *By* — CROISSILLE. *Annales des Mines. Sér.* 8, *Vol. IX., pp.* 665–668.

	Gold Exported.	Auriferous Pyrites Exported.	Copper Ore Exported.	Nickel Ore.	Cobalt Ore.	Chrome-Iron Ore.	Stibnite.
	Oz. Troy.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1872	2,189	...	...	...	...	...	...
1873	1,663	...	57	...	...	...	..
1874	280	...	665	...	...	...	...
1875	...	...	1,340	327	...	35	...
1876	600	...	2,622	3,406	1·5	...	...
1877	901	...	4,622	4,377	249·7	...	...
1878	1,089	...	6,024	155	38·9	...	...
1879	18	...	7,741	...	...	...	...
1880	...	...	3,441	2,528	...	500	...
1881	...	..	5,208	4,070	...	2,300	...
1882	...	20	3,385	9,025	327·0	3,670	...
1883	...	30	2,991	6,881	4,271·0	2,192	48
1884	...	35	2,060	10,888	3,467·0	2,710	880

M. W. B.

COMPARISON OF THE COSTS OF SEVERAL SYSTEMS OF TRANSMITTING MOTIVE POWER.

Comparaison entre les divers Systèmes de Transmission de Force motrice. *By* JULES LAURIOL. *Le Génie Civil, Vol. IX., pp.* 313–5 *and* 343–5.

The principal agents of transmission of motive power to a distance are electricity, hydraulic pressure, compressed air, and ropes, the less applied systems being coal gas, steam, rarified air, etc.

The cost of the unit of power transmitted depends upon (*a*) the cost of the motor power, (*b*) the useful effect of the mode of transmission, and (*c*) the cost of working and maintaining the system.

The cost of motive power per hour is assumed at (*a*) steam engines, small 4·5d., average 3d., large 1·2d.; (*b*) hydraulic power, ·2d.; and (*c*) gas engine (at 7s. per 1,000 feet), 4·5d.

The following table shows the cost per horse-power per hour utilized of transmitting 100 horse-power under the four chief systems:—

Motive Power.	System of Transmission employed.	Distance of Transmission in Yards.					
		109.	546.	1,093.	5,468.	10,936.	21,872.
		d.	d.	d.	d.	d.	d.
Steam ...	Electric	1·87	1·92	2·02	2·36	2·96	4·80
	Water pressure ...	2·36	2·46	2·72	4·20	6·03	9·97
	Compressed air ...	3·30	3·36	3·47	4·22	5·47	6·66
	Ropes	1·31	1·55	1·65	3·00	5·20	13·21
Hydraulic ...	Electric	·48	·50	·55	·65	·71	1·20
	Water pressure ...	·48	·57	·65	1·39	2·32	3·69
	Compressed air ...	·75	·83	·87	1·26	1·94	3·50
	Ropes	·26	·28	·31	·83	1·48	3·53

M. W. B.

ON EXPLOSIONS IN LAMPBLACK FURNACES.

By PROFESSOR ENGLER. *Journal für Gas Beluchtung*, 1886, *p.* 147.

In the Black Forest the materials used for the manufacture of lampblack are the residues of firwood, together with coal-tar, etc. The material is thrown into two slightly inclined ovens, and the gases carrying the lampblack pass first into a cooling chamber and then into a tower from which they pass into a chimney. Tar yields 25 per cent. and the firwood refuse 20 per cent. of lampblack.

The gases found in the cooling chamber, 3 feet from the ovens, are—

Carbonic acid	6·2 to 10·8 per cent.
Carbonic oxide	·5 to 1·4 „
Oxygen	6·2 to 13·4 „
Marsh gas	inappreciable.
Hydrogen	„

Lampblack and air are not explosive, but there is a possibility of the explosion of mixtures of lampblack, air, and combustible gases.

It has been ascertained that lampblack or powdered charcoal will cause explosions in air containing 2·5 per cent. of marsh gas or 3·5 per cent. of coal gas; and without lampblack, explosions are produced with 5·6 per cent. of marsh gas or about 8 per cent. of coal gas. It is evident therefore that the explosions cannot occur from the combustion of the gases and air, either with or without lampblack, during the ordinary working of the furnaces.

It is most probable that they chiefly occur during the lighting up of the furnaces, or if too large quantities of material are thrown in; and the remedy would accordingly be—more care in working, to ignite the materials as soon as they are placed in the furnace, and to carefully regulate the supply of materials whilst working.

M. W. B.

REMARKS UPON THE EXPERIMENTS OF THE PRUSSIAN FIRE-DAMP COMMISSION.

Sur les Travaux de la Commission Prussienne du Grisou. *By* MESSRS. MALLARD AND LE CHATELIER. *Annales des Mines*, *Sér.* 8, *Vol. IX.*, *pp.* 638–664. *Plate XVII.*

1.—COAL-DUST.

(*a*) *Coal-dust alone.*—The experiments show that shots placed near the floor of the gallery are alone capable of igniting dusts, and that this effect is not prevented by inclining the direction of the hole towards the roof. When the hole is stemmed with coal-dust instead of clay the length of the flame becomes greater for all the holes; thus—

Holes.	Length of Flame in Feet. With Clay Stemming.	With Coal-dust Stemming.
1	13·7 ...	70·7
2	26·5 ...	75·0
3	9·5 ...	75·0
4	13·7 ...	79·0
5	9·5 ...	94·4
6	62·0 ...	94·4
7	57·4 ...	79·0

Hansa dust was strewed with the clay stemming, and Gerhard dust with coal-dust stemming over the gallery for a length of 328 feet.

The position of the holes was as annexed. The use of coal-dust stemming has in all cases lengthened the flame of the shot; holes near the top, and pointing downwards, whose flame with clay stemming did not reach the floor and could not ignite the dust, have produced this effect when their flame was lengthened by the coal-dust of the stemming.

The most important question regarding coal-dust is whether the ignition of dust by a shot can be compared to that of powder fired by a fuze, and to admit that the inflammation produced at any point can be immediately propagated indefinitely. The Prussian Commission adopt this view, when they allege as beyond doubt that with the Neu-Iserlohn and Pluto dusts the length of the flame can be increased by increasing the length of the gallery strewed with dust. Consequently if all the galleries of a mine were covered with dust, they would all be traversed by its ignition at any point.

The experiments of the Prussian Commission do not, however, confirm this opinion. Thus with the Pluto dust:—

When the length of dust strewed in the gallery is (Feet.)	32·8	65·6	98·4	131·2
the length of the flame is about (Feet.)	113·5	139·7	177·1	190·2

It is true that in the last experiment the length of the flame still exceeds that of the dust strewed in the gallery, but if a curve be drawn with the lengths of dust as abscissæ and the lengths of flames as ordinates, it will be seen that the length of the flame approaches a horizontal tangent and cannot be far from 200 feet. It is evident therefore that the length of the flame cannot be indefinitely increased by increasing the length of the gallery strewed with dust. This is so true that for the less combustible dusts the length of flame has been determined, beyond which the increase of the length of the strewing produced no apparent lengthening of the flame.

The phenomenon of the ignition of coal-dust by a shot appears to be as follows:—In the part of the gallery reached by the powder gases, moving at a high velocity and endowed with a high temperature, the dust is violently thrown into suspension and ignites. The gaseous mass, thus ignited (considerably expanded by heat and increased by the partial distillation of the dust that has been thrown into suspension by the mechanical effects of the powder gases), expands into the gallery and extends to a distance proportional to the mechanical effects of the powder gases, and to the ease with which the dust in suspension is distilled. The mechanical effect of this jet of flame upon the dust of the gallery, situated at such distances as to escape the initial action of the powder gases, is small, and rapidly decreases until it is destroyed at a very short distance from the shot.

This opinion is confirmed by the small values of the mechanical effects. Thus, with a coal-stemmed shot, when the gallery was not strewed, the movement of the wagon (1,627 lbs.) varied between 7·8 and 15·7 inches. When the gallery was strewed with dust the wagon was moved from 7·1 to 23·6 inches, but with the exceptional Pluto dust it reached 100·4 inches.

The mechanical effect of the ignition of dust is therefore very small, and when it becomes greater for certain exceptional kinds of coal it is still much inferior to that of an explosion of fire-damp. Thus, while the wagon was moved 100·4 inches with Pluto dust, it was moved 314·9 inches (3·2 times further) under the effects of the explosion of 706 cubic feet of mixture containing ·07 of fire-damp.

The experiments of the Prussian Commission entirely confirm our opinions which follow:—Combustions of dusts are not, to speak exactly, explosions; these combustions, indeed, only produce mechanical effects entirely insignificant for most dusts, and always much less than those of fire-damp explosions, even for the most exceptional dusts. The combustion produced at any point does not extend indefinitely over the whole area covered with dust. The length of this ignition is proportional to the intensity of the mechanical action which has raised and ignited the dusts; this length is always limited, and is (under the effects of blown-out shots of ½ lb. of powder) about 65 feet for most dusts, and only reaches 200 feet in the case of very exceptional dusts; and an explosion which extends over a considerable distance is consequently *not* a dust explosion.

(*b*) *Fire-damp and Air.*—The limit of the inflammability of air and fire-damp is somewhat difficult to determine. From the Prussian experiments upon the length of the flame produced by a blown-out shot, stemmed with clay, passing into an atmosphere containing variable proportions of fire-damp, it is highly probable that explosion is produced between 6 and 7 per cent. of gas. It is found also that the agitation of the gas connecting the unburnt and burning gases exerts a most powerful influence in augmenting the velocity of propagation of the ignition, and that the conditions are very variable; it may therefore be assumed that in a large space the propagation of the inflammation may occur, in a more or less irregular manner, in a mixture containing ·056 of fire-damp.

(*c*) *Fire-damp and Coal-dust.*—The experiments of the Prussian Commission entirely confirm our expressed opinions that the influence of fire-damp upon the combustibility of dusts, if it is not altogether *nil*, is at least much less important than was at first assumed. It appears that so long as the proportion of gas contained in the air is not dangerous by itself, dusts have only a feeble influence. They only have the effect of augmenting the length of the flame of the shot and, consequently, the quantities of gas which may be ignited in the vicinity of its flame. The co-existence of coal-dust and fire-damp does not create any special danger when each of these bodies singly is not of itself dangerous.

2.—Safety Lamps.

The experiments of the Commission show that the cause of the danger arising from an internal explosion is not great for most of the lamps in use, such as the Davy, Boty, and Mueseler, consequently the conclusions of the Commission, which are based upon such a standard of safety, are of no practical value. They recommend the use of the Boty lamp, which is notoriously inefficient, as compared with the Mueseler and Marsaut lamps, when exposed to a mixture of air and fire-damp moving at high velocities.

3.—Influence of the Atmospheric Pressure upon the Issue of Fire-damp.

The experiments of the Prussian Commission have been carefully carried out, but their duration has been too short, probably owing to the great attention required in the observations.

The experiments appear to show that in working districts which are not in communication with large exhausted areas, the influence of the pressure of the atmosphere upon the quantity of fire-damp existing in the galleries is scarcely apparent; and that this influence is only experienced, in a very irregular manner, when enormous reservoirs more or less filled with gas and air, are in immediate communication with the workings.

M. W. B.

ON THE PRESSURE EXERTED BY WATER IN SOIL.

By L. Brennecke. *Zeitschrift für Bauwesen*, 1886, *p.* 101.

The results are given of a number of experiments upon the influence of capillary attraction in diminishing the pressure of water in sands of various degrees of fineness and in clay.

Examples are quoted of the varying resistances of different soils. At a colliery in Germany, when repairing the shaft under pneumatic pressure, at a depth of 48 feet below the level of surface water in a saturated clay sand, a pressure of ¾ atmosphere excluded the water instead of nearly double that pressure due to the head of water column. At another colliery the sinking was carried with a pressure of 2½ atmospheres, to a depth which was calculated to require 8 atmospheres.

It is suggested that the water was in these cases partly supported by the air pressure and partly by capillary attraction. M. W. B.

REUMAUX'S HYDRAULIC RAMS FOR LOWERING THE CAGE AT THE BOTTOM OF THE SHAFT.

Notice sur les Taquets hydrauliques, système Reumaux. By J. Wuillot. *Société des Ingénieurs sortis de l'École provinciale d'Industrie et des Mines du Hainaut. Sér.* 2, *Vol. XVII., pp.* 72–80. *Plates V., VI., and VII.*

Hangings-on, situated at different levels, connected by drop-staples or inclined galleries, afford great facilities for working, but necessitate great cost for labour, and are not always applicable. Vertical movement of the cage is consequently required in the pit.

M. Reumaux has invented a very simple form of hydraulic counterbalance, the power being obtained by utilizing the vertical height of the pit.

The apparatus consists of two pairs of hydraulic rams (one pair for each cage), which receive the cages, their descent being regulated by a "cataract," consisting of the variable opening of a tap. A column of water in the pit returns the ram to its initial position (ready for another cage) when the tap is opened. A tube of least resistance is provided, to save the apparatus from rupture in case of a heavy shock.

The apparatus has reduced a very high speed of the cage within a length of 4 feet. The "cataract" is an effectual break for the cages, and the velocity is reduced with such promptness and regularity that the lives of eight workmen were once saved, when, owing to inattention of the engineman, the cage went at ordinary working speed upon the counterbalance.

The apparatus consists of a metal cylinder, an iron ram with a head and automatic catches to carry the cage, and a tube of least resistance. The water working the ram is contained in a small iron tank, about 240 feet above the hanging-on, connected with the rams by a pipe of ·8 to 1·2 inch diameter. In frosty weather, a little warm water is placed in the cistern in the morning or the freezing point of the water may be lowered by the addition of a suitable soluble salt.

The price of the apparatus for a two-decked cage, with four tubs on a deck, is about £175 in France, the weight being:—Metal, 40 cwts.; bronze, 24 cwts.; and iron, 90 cwts.

The cage is stopped at any required level, by closing the tap at the proper instant; but, to make sure, M. Reumaux has added "keps" of a novel design.

The apparatus has been applied to cages with two and three decks at the Lons and Courrières collieries.

In the cases of cages with four decks, the great length of the rams and cylinders requires a rearrangement of the parts. The apparatus is then inverted and works by traction: this reduces the dimensions of the cylinder and the cost of the apparatus.

It will be seen that the hydraulic counterbalance is simple, ready, and efficient, and considerably reduces the operation of loading the cages; further, it greatly reduces the cost of making the hanging-on at the bottom of the pit; and generally it presents incontestable advantages which will make its application more extensive.

M. W. B.

VENTILATION OF MINES IN WESTPHALIA.

Sur l'Aérage des Mines dans le Bassin Houiller de la Ruhr (Westphalie). **By** L. BOCHET. *Annales des Mines, Sér.* 8, *Vol. X., pp.* 143-199, *Plate I.*

I.—INTRODUCTORY.

(*a*) *Statement of Accidents from Explosions in Coal Mines in Westphalia:—*

Year.	Collieries.	Explosions.	Killed.	Injured.	Per 1,000,000 Tons Worked.		Per 1,000 Workmen.	
					Explosions.	Killed and Injured.	Killed.	Injured.
1870	224	34	56	59	2·88	9·74	1·07	1·13
1871	237	40	50	79	3·15	10·15	·78	1·23
1872	252	36	24	63	2·49	6·03	·35	·92
1873	273	57	30	92	3·47	7·43	·37	1·15
1874	281	45	25	82	2·90	6·89	·30	·98
1875	269	52	16	69	3·06	5·00	·19	·82
1876	238	43	19	66	2·40	4·75	·23	·79
1877	223	37	20	39	2·09	3·33	·27	·53
1878	211	61	31	66	3·23	5·10	·42	·90
1879	206	83	43	111	4·07	7·56	·56	1·45
1880	203	62	81	108	2·76	8·40	1·02	1·36
1881	200	76	53	120	3·21	7·32	·64	1·44
1882	196	120	112	159	4·64	10·47	1·25	1·77
Average per yr.	232	57	43	86	3·10	7·09	·57	1·11

(*b*) *Geology.*—The Ruhr coal-field forms a belt, about 40 miles long, from the Rhine towards Unna, lying east and west; the width of the belt is greatest near Bochum, where it is nearly 12 miles. The Coal-Measures, whose thickness is about 8,000 feet, crop out on the south, and are covered on the north by Cretaceous marls, lying almost horizontal, whose thickness reaches 800 feet at Recklinghausen. The general inclination is about 7 degs. N.N.W. There are about 132 coal seams, of which about 74 are workable, with a mean thickness of 3·3 feet. The coal seams are not much disturbed by faults or flexures.

(*c*) *Fire-damp.*—Fire-damp is not usually found in the Ruhr coal-field. Some mines, however, are very dangerous, as shown by the following table:—

Collieries.	Number of Explosions from 1861 to 1882.	Killed.
Dorstfeld	32	4
Consolidation	29	6
Friedrich Wilhelm	26	9
Germania	26	20
Pluto	26	87
Kaiserstuhl	25	29
Neu-Iserlohn	16	155
	180	310

Sudden outbursts of gas are unknown and blowers are rare, and the accidents appear to be due to carelessness of workmen and masters, or natural causes. The issue of gas is usually very constant and regular. The following table shows the quantities of gas in a number of collieries:—

Collieries.	Percentage in the Return Air.		Volume produced per Cubic Foot of Coal Worked.		
	Fire-damp.	Carbonic Acid.	Fire-damp.	Carbonic Acid.	Total.
			Cub. Ft.	Cub. Ft.	Cub. Ft.
Rhein Elbe	·22	·71	1·32	4·25	5·57
Carolus Magnus	·08	·77	·88	8·50	9·38
Louise	·27	·19	5·96	4·19	10·15
Bonifacius	·45	·29	6·90	4·22	11·12
Tremonia	·17	·41	3·50	8·43	11·93
Massen	·25	·15	7·48	4·52	12·00
Consolidation	·23	·41	4·99	8·89	13·88
Prosper, No. 1	·04	·89	·61	13·65	14·26
Hörder	·24	·59	4·40	10·81	15·21
Neu-Iserlohn, No. 2	1·43	·32	13·27	2·99	16·26
Dorstfeld	·38	·38	8·67	8·67	17·34
Carl	·03	·85	·68	19·23	19·91
Pluto	·53	·66	11·40	11·88	23·28
Barillon	1·02	·86	17·17	14·47	31·64
Germania	·44	·40	16·62	15·11	31·73
Wolfsbank, No. 1	·05	1·84	·86	31·65	32·51
Shamrock	·83	·74	20·95	18·68	39·63
Neu-Iserlohn, No. 1	·35	·08	33·64	7·69	41·33
Kaiserstuhl	1·09	·25	47·50	10·89	58·39

If a map is prepared, showing all the collieries producing more than 2 cubic feet of gas per cubic foot of coal worked, it will be found that they lie in four belts in the direction of N. 65° E., running respectively through Dortmund, Herne, Hörde, and Essen. It is remarkable that these gaseous zones exactly correspond to four saddle-backs or anticlines in the Coal-Measures. These facts would support the theory that the importance of issues of fire-damp is more especially due to geological contortions and the resulting compressions, than to the composition of the coal.

(*d*) *Modes of Working.*—The coal is worked by forming pillars, from 10 to 15 yards wide, and of varying lengths, which are afterwards removed by a second working. The royalty attached to the mines varies from 120 or 150 acres to 1,700 or 1,800 acres, the average being about 560 acres. Hugo Colliery has a depth of about 1,950 feet, a few exceed 1,000 feet, the shallowest are about 600 feet.

II.—Ventilation.

(*a*) *Number of Pits.*—Most of collieries have only a single shaft, used for winding, pumping, ventilation, and ladder pits, divided by suitable partitions. The loss of air through the brattice is 67 per cent. at Carolus Magnus Colliery, and is usually from 30 to 32 for all the collieries with single shafts.

(*b*) *Ascentional Ventilation.*—The general rule is practised that the air shall descend by the downcast pit, and that its distribution in the workings shall be afterwards always in an ascending direction.

(*c*) *Splitting of the Current.*—Splitting the air is extensively carried out, both in seams and districts of seams, but this subdivision is occasionally pushed too far.

(*d*) *Volume of Air.*—Most of the well-arranged mines give each workman at least 70 cubic feet of air per minute, and some 100 cubic feet, but the majority are content

with 35 to 50 cubic feet. A horse is usually reckoned as equal to three men. The dilution of the gases is shown, by a previous table, where the proportions are not dangerous, but 7·14 per cent. was found in the Zollern Colliery, and 9·75 per cent. in the Tremonia Colliery, by the Prussian Fire-damp Commission.

III.—Direction of the Current.

(*a*) *Air-ways.*—The areas of the downcast and upcast shafts of the mines are occasionally in the ratio of 10 to 1, the most frequent ratio being 5 to 1. There are a few exceptions, where the upcasts are larger than the downcasts. Similar differences are found in the areas of the air-ways, used for intakes and returns. The average areas are—intakes, 30 to 40 square feet; and returns, 20 to 30 square feet; but there has been marked improvement made in recent years. The average length of the air-currents is estimated at 3,800 yards. The average value of the equivalent orifices is about 10 square feet.

(*b*) *Doors and Regulators.*—Wooden doors are used, one, two, or three in number, according to the needs of each case. Cloth doors are generally used where the strata is subject to "thrusts." Regulators are exclusively placed in the return air-ways.

(*c*) *Airing of the Workings.*—The air is exclusively led around the face in both whole and broken workings. The haulage roads are all closed off by doors, except towards the main return, consequently, they are only aired when the doors are opened. Sometimes the air is coursed, in one current, through the old workings. Brattice is used in single places to carry the air to the face. In the case of long drifts, wooden boxes, from 36 to 100 square inches in area, or iron tubes, from 10 to 30 square inches in area, are employed. If large volumes are required, wood or brick brattice is used.

(*d*) *Shaft Brattice.*—The shaft brattice is usually made of planks, spiked to buntons, the joints being carefully closed. Upon the average 31·36 per cent. of the air is lost by the imperfections of the shaft brattice.

(*e*) *Old Workings.*—Old workings are ventilated in a few cases, but generally they are built off.

IV.—Production of the Current.

(*a*) *Without Ventilators.*—A small number of mines are ventilated by natural means; in others, the ventilation is produced by boiler chimneys, underground furnaces, or by steam jets.

(*b*) *Ventilators.*—The mechanical ventilators now in use are:—Guibal, 40; Pelzer, 18: Winter, 13; Fabry, 9; Schiele, 4; Kaselowski, 2; Wagner, 1; Dinnendahl, 1; or 88 altogether, excluding those kept as reserve.

The Fabry fans are all about 10 feet wide, and 10 to 12 feet in diameter, with three wings, and run from 20 to 30 revolutions per minute.

The Guibal fans are usually about 30 feet diameter, but there are some about 40 feet, running 30 to 50 revolutions per minute. In recent installations, they are 23 feet diameter and 6½ feet wide, running at 75 revolutions per minute. The blades, usually eight, are now made of iron. They have usually two inlets, and no sliding shutter. The chimney is from 20 to 30 feet high, and its upper orifice from 6 to 8 feet square.

The Pelzer fan consists of an iron wheel, with 6 or 8 helicoidal blades, placed in the axis of the fan drift. Part of the fan is placed in the orifice of the drift, and part is outside the orifice. The first part acts as a screw, and exhausts the air in a direction parallel to its axis; and the second throws it at right angles to the axis by centrifugal action. The Pelzer fans are usually 8 to 10 feet diameter, and from 1 to 1½ feet wide.

The Wagner and Winter fans depend upon centrifugal force. They are of small diameter, without case, and rapid running. The blades are fixed, at an angle of 20 to

30 degs., to a central disc. They are made from 8 to 10 feet diameter, and from 6 to 15 inches wide, with 12 to 16 blades. The running speed varies from 250 to 400 revolutions per minute.

The Schiele fan runs at from 400 to 450 revolutions per minute. One is placed at a depth of 800 feet, 3·3 feet diameter, and it runs 600 to 700 revolutions per minute.

In the Dinnendahl fan the axis is vertical, and provided with eight helicoidal blades. The screw is 8 feet diameter, and driven by a Brotherhood engine, at 120 revolutions per minute, the fan running at 840 revolutions per minute.

The Kaselowski is similar to the Dinnendahl fan, the difference consisting in the form of the wheel.

The Kley fan is similar to the Guibal; it consists of a wheel 2·3 feet wide and about 30 feet diameter, turning upon a horizontal axis. There are 24 blades, each 4 feet deep, inclined at an angle of 5 degrees to the radius. This wheel turns in a spiral casing, connected with an expanding chimney. The inlet to the fan is 22 feet diameter. The peculiarity of this fan is the mode of admission of the air. The inlet is connected with a spiral chamber similar to that of the fan, and the air enters this chamber in a tangential direction. The air rotates in the outer chamber in the same direction as the fan, passes through the inlet in a helicoidal course, and continues its rotary movement through the fan into the chimney. The inventor claims a useful effect varying from 70 to 86 per cent.

The following table shows the useful effects of the various ventilators in use:—

	Percentage of Useful Effect.	
	Watergauge.	Power Applied.
Guibal	71·7	15·1
Winter	33·6	36·0
Wagner	39·4	51·6
Schiele	49·2	36·5
Pelzer	45·0	31·4
Dinnendahl	60·0	21·4
Kaselowski	34·0	31·1
Kley *(from the inventor)*	77·8	53·3
Fabry	—	25·1

M. W. B.

DRESSING ORE WITH AIR-JIGS.

Dry Ore Concentration. *By* JOHN HEARD, JUNIOR. *The Engineering and Mining Journal, Vol. XLII., pp.* 7-8.

The subject of pneumatic dressing of ores (in which air is used as the fluid medium instead of water in the jigs) is frequently considered as a Utopian solution to an impossible problem, rather than as an established fact. It has been frequently condemned, because all the experiments made in Europe have proved to be failures. In America, however, good results have been obtained. The data of the experiments are all lamentably incomplete, but they are the only ones that can be obtained.

Three principles have been applied to pneumatic dressing of ores:—

Horizontal continuous currents.

Vertical continuous currents, aspiration and blast.

Vertical intermittent currents.

The objections to the practical success of the first and second systems are that the action of the current is too brief, the ore particles interfere with each other, and there

is no opportunity of correcting defective performance. In the third system, each particle of ore is acted upon hundreds of times before reaching the "tails" and "heads" compartments.

The intermittent puff of air was first applied for ore dressing by Chubb, and since improved by S. R. Krom and T. H. Paddock.

The following figures should convince even the most opposed antagonists of dry concentration that the separation of ores from their gangue, and of ores of different densities from each other, can be effected simply, cheaply, and thoroughly, by S. R. Krom's air-jig:—

	Ore.	Concentrates.				Granular Dust.	Chamber Dust.	Totals.
		No. 1.	No. 2.	No. 3.	Totals			
Star Canon Mill—								
De Soto Mine, lbs.	66,800	1,013	1,092	515	2,620	11,998	..	14,618
Assay	£14 9 0	£144 10 10	£237 10 3	£240 18 2	...	£27 12 8	..	...
Value	£482 11 3	£73 4 2	£129 13 7	£61 1 5	£263 19 2	£165 15 6	..	£429 14 8
Sheba Mine, lbs.	38,150	1,072	1,077	644	2,793	2,881	..	5,674
Assay	£11 6 11	£88 4 4	£111 19 5	£156 1 7	...	£19 6 3	..	...
Value	£216 7 9	£47 5 8	£60 5 11	£50 5 1	£157 16 8	£27 16 4	..	£185 13 0
Seminole Mine, lbs.	3,260	55	49	48	152	..	..	152
Assay	£0 19 4	£6 9 3	£17 7 6	£27 0 5	...	..	..	...
Value	£1 11 6	£0 3 6	£0 8 6	£0 13 0	£1 5 0	..	..	£1 5 0
Manhattan Mill—								
First run, lbs.	88,151	3,456	2,584	1,322	7,362	7,353	6,484	21,199
Assay	£5 16 10	£16 19 3	£41 9 5	£40 16 10	...	£11 12 5	£9 14 9	...
Value	£257 12 8	£29 6 3	£70 13 5	£31 19 10	£131 19 6	£42 0 10	£31 11 5	£205 11 9
Second run, lbs.	31,823	1,550	1,309	771	3,630	3,374	2,283	9,287
Assay	£5 0 6	£20 2 1	£29 6 6	£24 3 9	...	£11 8 6	£7 4 11	...
Value	£79 18 9	£15 11 3	£19 2 8	£9 6 5	£44 0 4	£15 18 0	£8 5 4	£68 3 8
Third run, lbs.	102,228	5,832	5,413	2,967	14,212	13,428	7,341	34,981
Assay	£16 8 10	£56 4 7	£82 12 6	£75 1 9	...	£29 10 6	£21 19 10	...
Value	£840 1 8	£163 19 4	£223 4 2	£111 7 10	£498 11 4	£193 3 11	£81 15 0	£778 10 3

The capacity of each jig at Manhattan mill is 300 lbs. of ore, free from dust, per hour.

The most recent improvements are found in the Paddock air-jig, consisting of an inclined, adjustable, stationary deck, over which the ore passes from an adjustable hopper at the upper end to the discharge at the lower end. The air is forced through the cloth surface of the deck by bellows below it, whose blast is regulated both as to quantity of air and number of strokes.

The bellows is horizontal, and discharges into an air-chamber below the deck. There are suitable arrangements forming an air-tight joint, by which any lateral or longitudinal inclination can be given to the deck.

The deck consists of a cast-iron grating, through which the air passes from the air-chamber, and over this a piece of broad-cloth is stretched, and clamped firmly down. A grating, of $\frac{1}{16}$ inch brass strips on edge, is pressed upon the bed, parallel to a diagonal of the bed. These strips are placed from $\frac{3}{8}$ inch to $1\frac{1}{4}$ inches apart, and are from $\frac{1}{2}$ to $\frac{1}{4}$ inch high, according to the size of material treated. There is, above this, another grating of zinc strips, $\frac{1}{16}$ inch thick, $2\frac{1}{2}$ inches high, and from $\frac{3}{8}$ to $\frac{3}{4}$ inch apart, running parallel to the other diagonal of the deck, but not quite to the opposite side, where a 3 inch longitudinal trough guides the waste, scraped from the top of the ore bed, down the side towards the waste discharge.

The discharge is at the open and lower end of these two gratings, and the ore passes out and over an inclined plane, divided by two adjustable fingers, into "heads," "middlings," and "tailings."

The machine is made adjustable in all its parts; the length of the ore bed, length of stroke, revolutions, longitudinal and lateral inclination, and width of discharge, can all be regulated to suit the ore.

One of these machines was used at the Blue Hill mines, upon a material consisting of a chloritic slate containing copper and iron pyrites, galena, and some silver. The ore was very low grade, and was crushed between 60 and 100 mesh. The average contents were—copper, 1·32 per cent., and silver, 4 ounces per ton. The ore was first separated from the gangue, and the heads run over again to separate the galena from the other sulphurets.

Blende has been separated from galena, leaving less than 1 per cent. It is claimed that any materials can be separated by its means whose difference of specific gravity is more than 1·25.

The capacity of the Paddock air-jig varies with the closeness of the work and fineness of the ore. Fine sizes will run at the rate of from 1,000 to 1,200 lbs. per hour, coarse sizes (up to 35 mesh) from 1,500 to 2,000 lbs. per hour. Sizes above 140 mesh do not give satisfactory results. M. W. B.

ORE DRESSING WITH AIR BLAST.

Über Erzaufbereitung mittelst Gebläseluft (Luftseparation). *By* E. W. Neubert. *Jahrbuch für das Berg- und Hüttenwesen im Königreiche Sachsen, 1886, pp.* 71-83. *Plates I. and II.*

A system of dry ore dressing has been adopted at the Himmels Furst Mine, near Freiberg. The ore is spread over an endless belt, and subjected to blasts of air. The endless belt is made of india-rubber, 18·9 inches wide, carried by rollers 93·3 inches apart, and about 16 inches diameter, and moving at a velocity of 4·33 to 4·72 inches per second. The air pipe is placed upon one of the long sides of the belt, with five orifices, from which the blast is directed over the ore lying upon the belt. The orifices are 9·84 inches long and 3·93 inches apart. The ore is delivered upon the belt from a hopper, placed at one end of the belt, through distributing rollers. Four leather straps, ·19 inch wide, are stretched across the belt between the blast orifices. The surface of the belt subjected to the air is 74·8 inches long. On the other side of the endless belt are five bunkers, into which the lighter material is blown. The air is supplied from a blowing fan, 13·38 inches diameter, running at 1,250 to 1,300 revolutions per minute.

The products vary greatly; with low grade ore, containing a large proportion of gneiss, the first and second bunkers contain "tails," the third, fourth, and fifth intermediate products, and the material remaining upon the belt and thrown into the bunker at the end may be good ore or "heads." The intermediate products are worked over again.

The system is similar to that of washing in sluices, in which mixed material must be frequently washed to separate the valuable ores. For large works it would be preferable to erect two or three dressers, with five blowing orifices each, instead of a single machine with ten or fifteen blowing orifices.

The results of twenty experiments upon various classes of ores are given, together with analyses of the original ore, the "heads," and the "tails." The experiments

show that the process works efficiently with galena, which can be separated with a mimimum of loss; but there is a difficulty in the separation of iron pyrites and zinc blende.

The cost of the process is somewhat higher than the ordinary washing systems, but crushed ore, with 5 per cent. or more of galena, can be advantageously treated.

M. W. B.

POECH'S AUTOMATIC GATES FOR WINDING SHAFTS.

Poech's Automatische, von der Förderschale unabhängige Schachtverschluss-Vorrichtung. Berg-und Huettenmœnnische Zeitung. 1886. *No.* 50, *p.* 523. *Plate VIII.*

The arrangement consists of light iron gates, worked by means of ropes from the axle of the winding engine. The gates are hung by ropes from a drum placed above the level of the flat sheets; the axle of this drum is driven direct from the winding engine by a special rope. The slack of this rope is taken up by a sliding pulley between the pit and the engine.

The apparatus is applied to a shaft 328 feet deep. The rope drum is 98·42 inches diameter, the axis for the motor rope is 9·84 inches diameter, the drum for lifting the gates is 29·53 inches, and its axis 11·81 inches diameter. The gates weigh 37½ lbs., and the sliding pulley 35¼ lbs.

M. W. B.

ACCIDENTS TO STRUCTURES BUILT WITH MAGNESIAN CEMENTS.

Note sur les Accidents constatés dans divers Ouvrages d'Art, par suite de l'Emploi de Ciments magnésiens. By Messrs. Leon Durand-Claye and Debray. *Annales des Ponts et Chaussées, Series* 6, *Vol. XI.*, 1886, *pp.* 845-856, *and* 1 *plate.*

By an official circular of July 18, 1876, the French Government, in such works as bridges, sluices, quay walls, etc., erected in soft water or out of the water, as well as in those parts of constructions upon the coast placed above the level of high tides, allowed the use of cements containing notable proportions of magnesia.

One of these cements, prepared at Campbon (Loire-Inférieure), at various times has been analysed as under:—

Date of Analyses.	1876. Jan.	1876. April.	1883. Dec.	1884. June.	1885. April.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Silicious sand ...	1·05	—	—	·35	·80
Combined silica ...	15·00	14·80	18·30	20·70	18·20
Alumina	11·15	8·00	2·95	3·35	4·60
Peroxide of iron ...	2·40	4·60	3·60	3·65	4·15
Lime	52·65	47·30	44·80	43·30	43·95
Magnesia	16·20	24·30	28·15	26·70	26·50
Sulphuric acid ...	·45	·60	·30	·15	·45
Loss	1·10	·40	1·90	1·80	1·35
	100·00	100·00	100·00	100·00	100·00

This Campbon cement was used in the construction of the bridges upon the railway from Questembert to Ploërmel; but about the end of 1882 (one year after the opening for traffic) it was found that the arches of these bridges were being subjected to

abnormal movements, and fissures were produced. These continued to open until strong centres were placed under the arches, and after examination, the arches were taken down. The official report was to the effect that owing to the expansion of the cement the joints of the arches were enlarged and destroyed. There was a marked fissure at the line of separation between the arch and the buttresses.

The same cement was used in both abutments and the left hand foundation of a bridge, with iron arches, at the station at Nantes. This bridge was finished in 1883, and in 1884 two fissures were found in the left hand abutment. Since then the fissures continued to multiply until 1885. It appeared from observations that the dislocations were all due to enlargement of the left hand foundation and both abutments, without any settlement. The width of the left hand abutments was increased by many inches, and the fissures had a constant width from top to bottom. The beds remained horizontal, and the largest fissure (1·6 inches wide) was continued down into the quay wall. Fissures were also formed in the abutment on the right hand side, which had been built with the Campbon cement; but the foundations (in which another cement had been used) were sound.

Numerous examples of similar accidents produced in other structures have been noted, in which Campbon cement had been used.

Experiments have been made in order to test whether the accidents are due to the exceptional proportion of magnesia, or wholly due to the magnesia itself.

Cements of well known quality were made into paste, and placed in thin glass tubes, one series pure, and the others mixed with proportions of calcined magnesia varying from 2 to 35 per cent. In one set the magnesia was mixed with the cement when cold; in the second, the cement and magnesia were mixed and calcined together. Half of the tubes were kept in the air, and half were filled with water. In varying lengths of time, the tubes of cement and magnesia filled with water were burst under the action of the magnesia; whilst those in air, and those of pure cement in air or water, were all uninjured. Similar results were obtained from cements containing magnesia naturally, as in that produced at Campbon.

The experiments evidently prove that a large proportion of magnesia, contained in the cements, is the cause of the accidents happening to the structures in whose construction they had been employed. It would appear that the magnesia (contained in the stones used for the manufacture of cement) does not combine with the silicious matter whilst in the kiln. This magnesia, when moistened, only hydrates very slowly; this is accompanied with considerable increase of volume, which produces the swelling of the mortar. Consequently, such cements should not be employed where they are exposed to action of water or moisture. M. W. B.

EXPERIMENTS UPON WINDING WIRE-ROPES.

Ergebnisse von Zerreissungs-Versuchen mit Förderseilen. *By* A. Kás. *Oesterreichische Zeitschrift für Berg- und Hütten-wesen*, 1886, 171–175 *and* 192–194.

The material of the ropes tested was patent crucible steel, of English or German manufacture, with a tensile strength between 148,500 and 193,500 lbs. per square inch and a diameter from ·074 to ·110 inches.

The experiments were made upon new wire ropes, and upon worn ropes with no broken wires and with broken wires.

The experiments showed that the tensile strength was slightly increased by the twisting together of the strands. M. W. B.

A NEW SAFETY CARTRIDGE FOR MINES.

Sprengpatrone für Bergwerke, gefüllst mit Schwefelsaure und Zinkstaub. Glückauf, No. 16, 1886.

This invention of Dr. Kosman of Breslau depends for its action upon the rapid evolution in the bore-hole of a large volume of hydrogen gas, the resulting pressure of which is to be used to detach the coal or stone. The cartridge consists of a glass bottle with a restriction or neck in the middle, dividing it into two portions, communicating through an opening about $\frac{1}{2}$ inch in diameter. The volume of the lower and larger space is to the volume of the other space as four to one. The larger space is filled with commercial sulphuric acid diluted with an equal volume of water; the inner neck is closed with a cork, and it is then handed to the miner for use. The hole having been bored in the coal or stone is well clayed over in the inside, so that all leakage of gas through fissures and cracks is prevented. The upper part of the cartridge is then charged with zinc, and an iron pricker laid in, passing through the zinc, and touching the cork in the inner neck. The outer neck of the cartridge is closed with clay, and it is then placed in the hole, which is carefully stemmed with clay, leaving one end of the pricker projecting.

The shot is fired by striking the pricker with a hammer, so as to drive in the cork or to break the glass at the inner neck; the result is that the acid and zinc are mixed, and accompanied with formation of large volumes of gas.

The pricker is tapered, so that when driven in it keeps tight in the clay stemming, and prevents the escape of gas. The zinc used is the bluish-grey powder collected in the condensing flues of zinc distilling furnaces.

Dr. Kosman claims that a cartridge 7 inches (180 millimetres) long and 1 inch (25 millimetres) diameter charged with 3 cubic inches (50 cubic centimetres) of diluted sulphuric acid and 185 grains (12 grammes) of zinc dust will produce 119 cubic feet (3·37 cubic metres) of hydrogen gas; the production of this volume in a space of $5\frac{1}{2}$ cubic inches (90 cubic centimetres) would create a pressure of more than 37,000 atmospheres.

*[This enormous pressure cannot, however, be produced. According to the well-known formula—

$$Zn + H_2SO_4 = ZnSO_4 + H_2,$$

65·2 grains of zinc will produce 2 grains or 1·358 cubic inches (65·2 grammes of zinc is the equivalent of 2 grammes or 22·32 litres) of hydrogen; 185 grains (12 grammes) of zinc dust will contain 154 grains (10 grammes) of metallic zinc, and the volume of hydrogen produced will be 209·13 cubic inches (3·423 litres). If this volume be compressed into a space of $5\frac{1}{2}$ cubic inches (90 cubic centimetres) the pressure will not be 37,000, but only about 38 atmospheres, which cannot possibly be exceeded.]

M. W. B.

WATER CARTRIDGES.

Zur Frage der Schiessarbeit. Glückauf, No. 90, 1885.

Experiments have been made at the Bonifacius and Zollverein Collieries for the prevention of explosions of gas or coal-dust due to shot-firing. The conclusions deduced from them were:—That the use of dynamite and blasting powder in the presence of fire-damp and coal-dust is dangerous, until some certain means is invented for preventing the production of flame. The very simple water cartridge does not afford, unfortunately, a sure remedy for this purpose. M. W. B.

* Note of Translator.

THE HEAT OF COMBUSTION OF COAL.

Sur la Chaleur de Combustion de la Houille. By MESSRS. SCHEURER-KESTNER AND MEUNIER-DOLLFUS. *Annales de Chimie et de Physique, Sér.* 6, *Vol. VIII., pp.* 267–281.

In 1870 attention was drawn by the authors to the fact that it was impossible to compute (even approximately) the heat of combustion from the chemical composition of coal. Calculations made in accordance with Dulong's formula, which makes allowance for the presence of oxygen in the fuel, are found to be less than experimental results.

In the former experiments the fuel was reduced to powder, and various precautions adopted to secure complete combustion of the coal. In the present experiments the calculations are based upon the results given by the purely combustible matter, allowances being made for moisture and ash, and pieces of coal were used. It was found that pure coal from the same colliery possessed the same heat of combustion, irrespective of the ash.

The gases used in the experiments were either pure oxygen, or mixtures of oxygen and nitrogen or air, and were quite dry.

The coals used were of varied character, ranging from—

	Per Cent.
Carbon	76·87 to 96·66
Hydrogen	1·35 to 5·10
Oxygen, nitrogen, and sulphur ...	1·99 to 18·45

The following results are extracted from their numerous experiments:—

Description of Coal.	Composition.			Heat of Combustion. (Centigrade Units.)	
	C.	H.	C+N+S.	Experiment.	Calculated.
French—					
Ronchamp IV. ...	87·49	5·10	7·40	8,946	8,552
Creuzot	88·48	4·41	7·11	9,623	8,431
Blanzy	87·02	4·72	8·26	9,111	8,404
German—					
Louisenthahl ...	76·87	4·68	18·45	8,215	7,575
English—					
Bwlf	91·08	3·83	5·09	8,780	8,473
Powel	92·49	4·04	3·47	8,949	8,649
Russian—					
Groucheski	96·66	1·35	1·99	8,259	8,203
Galoubosski	82·07	5·07	12·26	8,021	8,154

M. W. B.

THE VELOCITY WITH WHICH A GAS PASSES FROM ONE PRESSURE TO A LOWER PRESSURE.

Recherches Expérimentales sur la Limit de la Velocity que prend un Gaz quand il passe d'une Pression a une autre plus faible. By G.-A. HIRN. *Annales de Chimie et de Physique, Sér.* 6, *Vol. VII., pp.* 291-349. *Plate II.*

From an examination of the classic formula $V = k\sqrt{2gh}$, the author concludes that it should be verified by experiment, as he considers it probable that it ceases to be an approximation under certain conditions.

The apparatus employed is very fully described and illustrated by a plate; it consisted essentially of a small gasometer. All the experiments were made upon common

air at atmospheric pressure augmented by the pressure upon the gasometer. The orifices experimented upon were two obtuse cones in thin plate, two converging conical mouthpieces, and another consisting of a converging cone with a glass mouthpiece.

The results of the experiments are fully detailed and compared with four empirical formulæ based upon theoretical views.

The conclusions of the author are that the true law of the issue of gas, for any difference of pressure, is unknown. It would be possible to deduce an empirical formula, which would be a close approximation to the experiments, but the author has not made one.

He, however, points out that the theoretical velocity of atmospheric air passing into a vacuum is 1,591 feet per second, whilst by experiment against a small pressure a velocity of about 20,000 feet was obtained. M. W. B.

WALCHER MINING WEDGE.

Kohlenbrech apparat, patent Walcher. *By* EUGEN RITTER VON WURZIAN. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1886, *pp.* 283–87, *and Plates VI. and VII.*

This machine wedge, weighing about 200 lbs., consists of two parts—the wedge, which is placed in a hole bored in the coal, and a hydraulic pump with a pressure cylinder. The wedge, worked by two men, requires a hole 4·6 inches diameter and 39 inches long, which is bored in about ten minutes, by a double-ratchet drilling machine, weighing about 110 lbs.: the drill used is about 48 inches long.

The wedge has three parts—the two feathers and square central bar, with six hard cast steel studs, which open the parts of the wedge when the central bar is drawn out by the pressure cylinder.

This wedge is employed at the Archduke Albert's Collieries, near Teschen, and has received general approval. It is claimed that mining is not rendered more costly by its use. M. W. B.

HELLHOFFIT AND CARBONIT.

Versuche mit den Sprengstoffen Hellhoffit and Carbonit. *By* —. MARGRAF. *Zeitschrift für das Berg-, Hütten-, u. Salinen-Wesen. Vol. XXXIV., pp.* 59–72.

HELLHOFFIT.

This explosive, the invention of Captain Albert Hellhoff, has two components, and is prepared from one part of dinitrobenzene $C_6H_4(NO_2)_2$, and $1\frac{1}{2}$ parts of nitric acid HNO_3, or of one part of mononitrobenzene $C_6H_5NO_2$, and $2\frac{1}{2}$ parts of nitric acid HNO_3, in all cases by weight. Hellhoffit is a dark red or brown coloured liquid, which is ready for use when absorbed by kieselguhr, etc.

When prepared in this manner hellhoffit is said to have the following advantages over dynamite:—(1) cheaper in price; (2) may be harder and more closely stemmed into the hole; (3) it does not explode coal dust or fire-damp if there is less than 10 per cent. of gas, whilst dynamite explodes $4\frac{1}{2}$ per cent. of gas; (4) it does not sweat out of the cartridge, and if it did there is no danger, as it is not explosive by percussion; (5) its use produces more round coal; and (6) the products of explosion are not unpleasant to the lungs.

CARBONIT.

This explosive is formed from nitrobenzene, but the process is not described. It is of a greyish brown colour, and plastic like dynamite, with a specific gravity of 1·3. It is said to have all the advantages of hellhoffit, without being subject to spontaneous decomposition. M. W. B.

PRICES OF COAL AND COKE AT THE RIVE-DE-GIER.

Prix-courants des charbons et cokes à la Rive-de-Gier. Bulletin de la Société de l'Industrie Minérale, Sér. 2, Tome XV., p. 529, and Sér. 3, Tome I., p. 345.

	Price per Ton of 2,204 Lbs. Aug. 1st, 1886. s.	d.		Jan. 1st, 1887. s.	d.
Large hard hand-picked	25	6	...	25	6
Smaller	19·2 to 21·6		...	19·2 to 21·6	
Nuts	16·0 to 20·8		...	16·0 to 20·8	
—— (?) (Malbroug)	12·8 to 18·4		...	12·8 to 17·6	
Small	10·4 to 16·0		...	10·4 to 15·2	
Patent fuel (agglomérés)	12·8 to 15·2		...	12·8 to 15·2	
Coke, washed	24·0		...	22·4	
„ unwashed	14·4 to 15·2		...	14·4	

J. H. M.

THE KLEY VENTILATING FAN.

Ventilator Kley. Zeitschrift für das Berg-, Hütten-, u. Salinen-Wesen im Preussischen Staate. Vol. XXXIII., pp. 241, 242.

Colliery.	Fan.	Revolutions.	Volume of Air per Minute.	Water-Gauge.	Horse-power. In the Air.	Horse-power. Of Engine.	Useful Effect.
			Cubic Ft.	Inches.			Per Cent.
Heinitz	Guibal: 32′ 9″ diam. 9′ 10″ wide	40	45,130	1·574	12	29·4	40
		60	71,100	3·346	38	85·5	44½
Schmidt-Manushall	Kley: 29′ 6″ diam. 3′ 7″ wide	40	37,040	1·259	7·45	13·82	54
		62	57,410	2·283	20·95	37·44	56

M. W. B.

ATMOSPHERIC PRESSURE AND THE ISSUE OF FIRE-DAMP.

Berich über Versuche betressend den Einfluss des wechselnden Luftdruckes auf die Entwickelung des Grubengases. By C. Hilt. *Zeitschrift für das Berg-, Hütten-, u. Salinen-Wesen im Preussischen Staate. Vol. XXXIV., pp. 72-90. Plates in text, f, g, h, i, k, l.*

These experiments were made for the Prussian Fire-damp Commission, and are said to show the following conclusions:—That an increase or decrease of pressure is followed within twenty-four hours by a decrease or increase respectively in the issue of fire-damp or carbonic acid gas from the coal.* M. W. B.

* See "Influence of the Atmospheric Pressure upon the Issue of Fire-damp," p. 15 of Abstracts in this volume.

AN INQUIRY INTO THE CONDITION OF THE BELGIAN MINERS.

Enquête sur la condition des Ouvriers Mineurs en Belgique. Tract No. 45, published by Paul Dutilleux of Douai, October, 1886, pp. 514–522.

This tract is founded on the documents presented by the Belgian Coal Trade Associations to the Commission appointed in April, 1886, to inquire into the coal trade crisis.

The Charleroi and Sambre Association are of opinion that the depression of trade is due to an excess of production over demand, and has affected capital more than labour, as is shown by the following Table:—

Years.	Average Selling Price.	Yearly Wage per Workman.	Receipts per Ton.	
			Capitalist.	Workman.
	Frs.	Frs.	Frs.	Frs.
1850	8·31	477	1·26	3·76
1855	12·78	785	2·39	6·63
1860	11·56	755	1·35	5·99
1865	10·69	787	1·28	5·34
1870	11·07	878	0·85	5·93
1875	15·80	1,179	0·93	8·67
1880	10·15	917	0·22	5·58
1885	8·88	796	0·43	4·74

From which it will be observed that whilst the capitalist received about 1 franc per ton from 1850 to 1875, since the latter date he has only obtained from 0·22 to 0·43 franc. The workman, on the other hand, is now receiving more than he did in 1850. Omitting 1872–76—an abnormal period—M. Pirmez shows that in Hainaut—

From 1860–71 the average yearly profits were ...	10,000,000 francs.
„ „ „ wages „ ...	52,000,000 „
Total	62,000,000 „
1877–83 average yearly profits were	2,000,000 francs.
„ „ wages „	71,000,000 „
	73,000,000 „

In other words, capital has suffered much more than labour from the depression in the Belgian coal trade.

All the Coal Trade Associations seem to be of opinion that the miserable condition of the men is in part due to their drinking habits, and propose alterations in the laws affecting public houses. J. H. M.

STONE TUBBING.

Wasserdichte Schachtmauerung mit Steinernen Keilkranzen. Zeitschrift für das Berg-, Hütten-, u. Salinen-Wesen im Preussischen Staate. Vol. XXXIII., pp. 224, 225.

Stone tubbing has been employed in a deep sinking at the Osterwald Colliery. A ring consisted of ten segments, all the joints being wedged with wood. M. W. B.

THE MINING CRISIS IN BELGIUM.

La Mine aux Mineurs. Analyse et Extraits de la Brochure de E. HAVEU "*La Crise Charbonnière Belgique.*" *Tract No. 46, published by Paul Dutilleux of Douai, November*, 1886, *pp.* 526–531.

Belgium is placed at a disadvantage when compared with other countries from the thinness of its seams of coal. During the three years 1881–83 the production per person employed per annum was:—

	Tons.
Belgium	169
France	190
North and Pas de Calais	207
Prussia	273
Rhur	287
England	311

And the production per person employed below ground was:—

	Tons.
Belgium	244
North and Pas de Calais	264
Rhur	372

The coal trade has had its periods of prosperity, the most brilliant being that following the Franco-German war. During the three years 1872–74 the Belgian colliery owners made a profit of 152,000,000 francs, wages amounted to 380,000,000 francs, giving each workman 1,199 francs per annum. The value created was more than 787,000,000 francs, which was divided as follows:—

48·20 per cent. in wages,
32·49 „ in other working expenses,
19·31 „ to the coal owners.

1875 was a year of transition, and during the last ten years the coal trade has been in a depressed condition.

From 1876–84 (nine years) the profits (about half the collieries have made profits) were ...	92,375,000 francs.
The losses	73,471,000 „
Net profits	18,904,000 „

Equal to a profit of about 2,100,000 francs per annum. The value created was 1,505,981,000 francs, of which the workmen received 800,000,000 francs, or 920 francs per man per annum. This 1,506,000,000 was divided as follows:—

56·64 per cent. in wages,
42·13 „ in other working expenses,
1·25 „ to the capitalist.

The small profits realised by the coal owners have resulted in the investment, during recent years, of much smaller sums in new work than formerly. Thus there was spent in—

	Francs.
1876	27,000,000
1880	17,000,000
1885	12,000,000

The author finally discusses the state of the working classes generally, and asks if these numerous disturbances occurring not only in Belgium, but in other parts of the world as well, are due to the industrial depression only, or if they are not the prelude to a violent anarchical movement throughout the world. J. H. M.

PRICES OF COAL AND COKE AT ST. ETIENNE.

Prix-courants des Charbons et Cokes à St. Etienne. Bulletin de la Société de l'Industrie Minérale, Sér. 2, Tome XV., p. 529, et Sér. 3, Tome I., p. 345.

	Price per Ton of 2,204 Lbs. Aug. 1st, 1886.	Jan. 1st, 1887.
	s s.	s. s.
Large hard hand-picked, first quality ...	26·4 to 28·8	23·2 to 24·0
Large tender ,, good quality ...	21·6 to 24·0	
,, ,, ordinary quality..	20·8	21·6
Treble nuts, first quality	16·8 to 18·4	17·6 to 20·4
,, second quality	15·2 to 16·0	16·0 to 16·8
Nuts, washed	13·6 to 16·0	14·4 to 17·2
,, unwashed	10·4 to 12·8	10·4 to 12·8
Peas (?) (grenettes)	9·6 to 11·2	11·2 to 12·0
—— (?) (Malbroug)	14·4 to 16·0	14·4 to 16·0
Gas coal, first quality	14·4 to 16·0	14·4 to 16·0
,, second quality	12·0	12·0
Blacksmith's coal, first quality	17·6 to 20·0	17·6 to 20·0
,, ,, second quality	15·2 to 16·0	15·2 to 16·0
,, ,, washed	14·4 to 15·2	14·4 to 15·2
House coal, first quality	10·4 to 11·2	10·4 to 11·2
,, second quality	8·8	8·8
Small coal for large forgings	8·8 to 9·6	8·8 to 9·6
,, ,, lime burning	6·4 to 7·2	6·4 to 7·2
,, average quality	7·2 to 8·0	7·2 to 8·0
Patent fuel (agglomérés)	12·8 to 15·2	12·8 to 15·2
Washed coke, first quality	20·8 to 24·0	20·8 to 24·0
,, second quality	20·0 to 20·8	19·2 to 20·0
Coke for blast furnaces	14·4 to 15·2	14·4
Small coke of good quality for house ...	15·2 to 16·0	15·2 to 16·0
Small coke	7·2 to 8·0	7·2 to 8·0

J. H. M.

THE SALT MINES OF ROUMANIA.

Etude sur les Salines de Roumanie. By MAXIME PELLÉ. *Annales des Mines. Sér. 8, Vol. X., pp. 270-310. Plates III. and IV.*

1.—HISTORICAL.

These mines have been worked from very remote times, which is proved by the numerous sites of abandoned workings. The Government have a monopoly of the salt mines, which were and are still worked by convicts. The old mode of working was by sinking a pit through the clay, which was gradually enlarged in the salt until it might reach a diameter of 60 yards.

2.—GEOLOGY.

Little is known of the geology of Roumania, and examinations have never extended beyond particular districts. There are, however, three distinct regions.

The plains consist of alluvium and Pliocene formations.

The hills of Miocene formation are in three groups. Congeries beds, marked by thick beds of yellow sandstone and sands, containing blocks of hard sandstone, and conglomerates containing chlorite, mica, quartzite, and gneiss. The chief fossils are:—

Vivipara concenna, V. michaeli, V. sphoeroïdalis, Valvata piscanalis, Melanopsis acicularis, Congeria porumbari, etc. Paludine beds form the higher hills, comprising grey or yellow clays, marly and sandy schists, fine sandstones, either coloured yellow with sulphurets or black by impregnations of hydro-carbons. Petroleum is chiefly found in these paludine beds, most abundantly in four horizons, the lowest of which is richest in gas and oil. The chief fossils are:—Vivipara Sadleri, V. grandis, V. bifarcinata, Bithynia croatica, Melanopsis Sandbergeri.

The argillaceous salt formation is found below the paludine beds, and will be described separately.

The mountains are of Eocene and Cretaceous age. The Eocene beds are generally fine sandstones and conglomerates, and are greatly contorted. The Cretaceous beds are thick sandstone, corresponding to the middle chalk, and contain traces of ammonites.

The argillaceous salt formation is always found under the paludine beds; it is very thick and highly contorted. All the beds are more or less impregnated with salt and gypsum. They can be divided into two series.

The lower series is formed of greenish argillaceous shales covered with micaceous sandstones or sandy schists. The upper series consist of reddish clays, with occasional thin sandstones; they are often contorted, and occasionally are absent.

The workable beds of salt are usually of lenticular form, covered by the upper clay of the series. They are very thick and have never been pierced, although workings have reached a depth of 650 feet.

The mineral salt of Roumania is of variable composition, as shown by the following analyses of specimens from the four salt mines:—

	Slanic.		Doftana.		Tirgu-Ocna.		Grandes-Salines.	
	Best.	Ordinary.	Best.	Ordinary.	Best.	Ordinary.	Best.	Ordinary.
NaCl ...	99·830	97·163	99·378	97·020	99·040	96·920	99·878	94·844
MgCl ...	...	·007	·002	·008	·003	·006	...	·004
CaO, SO_3 ...	·013	1·536	·234	·745	·375	1·159	·046	·924
NaO, SO_3 ...	...	·277	·310	·965	·484	·536	...	2·329
HO	·089	·162	·074	·106	·089	·120	·074	·118
Silica and clay	...	·359	...	1·140	...	1·246	...	1·739
	99·932	99·504	99·998	99·984	99·991	99·987	99·998	99·958

Traces of protoxide of iron, strontian, bromine, and hydro-carbons are also found.

The best salt from Slanic is very white, and is used for domestic purposes; the other qualities are used for salting, cattle, and vine culture, etc.

3.—Modes of Working.

The salt mines have been worked by two systems.

The ancient method was by bell pits, now entirely abandoned.

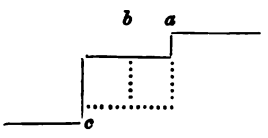
The modern system produces more salt from the deposits, and consists of driving galleries in the upper part at right angles to each other, leaving pillars between them. These galleries are driven 10 feet wide and 12 feet high, and form the upper part of the workings, the floor is then removed and a lateral inclination given to the sides until the galleries attain the required width, below which the sides are kept vertical. The roof of the galleries is kept about 130 feet below the top of the bed of salt to avoid irruptions of water. A balcony is placed in the upper part of the galleries, about 6 feet from the top, to allow of its constant inspection. Below this the sides have an inclination of about 60 degrees, until the galleries are about 160 feet wide. The result is to leave pillars of salt about 150 feet by 200 feet square.

4.—Hewing.

The floor of the gallery is arranged in steps, whose upper surface depends upon the cleavage of the salt. The hewers are provided with steel picks, weighing about 8 lbs., one end pointed, and the other with a chisel 3 inches wide, the handle being from 12 to 18 inches long. A block on the edge of the step, 1 foot wide and 2 to 4 yards long, is then nicked round to a depth of about 1 foot. A larger number of workmen then begin to strike the face of the step, at the base of the block to be removed, with 5½-lb. hammers, until they know by sound that the block is ready for removal by wedges driven into the face of the step. The prices paid are:—1s. 3d. per ton where the mines are lighted by electric means, and 1s. 5d. per ton where the men find their own light. The sides are dressed by special men at the rate of 4d. per square yard.

In the narrow galleries the centre is nicked out and the sides wedged off, until the full width is attained by the final dressing of the sides, costing in all about 4s. per ton.

Mechanical cutting machines are also employed, which cut the mineral salt into cubes about 1 foot on the side. They are made by Messrs. Frank Reska, of Prague, and are used in Austrian salt and coal mines. Two machines are used at the Slanic salt mines. One machine, with two vertical saws, makes the cuts *a* and *b* to a depth of 1 foot, and 1 foot apart. The second machine, with a horizontal saw *c*, moves along the face of the step, and detaches the first prism, which is broken up by picks into lengths of 1 foot, weighing from 110 to 130 lbs. each. The remaining prism is removed by the second machine in the same manner. A third machine, with vertical saw, has also been introduced for cutting the prisms into cubes of 1 foot in the side. All the machines are run on rails along the step in course of working, and are driven by compressed air.



The cost of working with the machine is:—

	s.	d.
2 men at air compressor and boilers, and 6 underground, to attend to machines, lay the way, etc. ...	10	8
Hand work below first step	1	7
Wood fuel	25	0
Stores	6	9
Repairs, etc.	1	2
Total	45	2

The produce will be about 30 tons of salt, at about 1s. 6d. per ton.

The total cost of the machine-cut salt, including redemption of cost of machines, is about 2s. 2d. per ton. The extra cost above hand work is more than compensated by the decreased waste in working and the handy form of the salt cubes.

5.—Carriage and Winding.

The salt is carried on small trams, running on rails, and is drawn to the surface by horse gins or steam engines. Rope guides are fitted into some of the shafts. Tramways are used upon the surface.

6.—Sundries.

Ventilation.—The natural ventilation is usually excellent.

Pumping.—Small pits are sunk and levels driven in the upper clay, for the purpose of keeping the water out of the mines.

Lighting.—Oil and tallow are usually employed, but the Slanic salt mine is lighted by electric means.

7.—Statistics.

The production for a few recent years has been :—

	Tons.		Tons.		Tons.
1864 ...	45,400	1876 ...	73,000	1882 ...	78,754
1868 ...	51,400	1880 ...	80,000	1883 ...	86,644
1872 ...	65,000	1881 ...	79,029	1884 ...	70,408

The total cost of working per ton for the four mines has been :—

	1881.	1882.	1883.	1884.
	s. d.	s. d.	s. d.	s. d.
Management ...	1 10	1 8½	1 7	2 0
Hewing, etc. ...	3 1	3 2½	3 5	3 8½
Sacks	1 1	1 4	7	10
Sundries	9	9	8	9½
New plant	2 11½	1 9½	1 11½	2 3
Totals ...	9 8½	8 9½	8 2½	9 7

The selling prices vary from 55s. to 70s. per ton at the mines, but the salt is sold at reduced prices to certain industries.

The number of workmen employed is about 600, of whom one-half are hewers. Ten hours are a day's work. Free men are paid 1s. to 1s. 7d. per day; convicts are paid from 6d. to 10d. per day. M. W. B.

TELLIER'S SYSTEM OF SUPPORTING STONE DRIFTS.

Modes de Soutènement mobile pour Galeries souterraines. By Léon Tellier. *Société des Ingenieurs sortis de l'École Provinciale d'Industrie et des Mines du Hainaut. Sér.* 2, *Vol. XVII., pp.* 105–118. *Plates IX., X., and XI.*

This system of supporting stone in drifts consists of two beams of H-iron, curved to a radius of 9 feet, and hinged together at one end by a bolt, round which they turn like a pair of callipers. When the gears are erected, the two long arms form a pointed arch. The short arms carry a longitudinal balk. The upper part of the system is then locked together with two punch props and two wedges, one on each side. The two legs rest upon sills of old timber. Their circumference is then covered with backing deals, carrying the dry stone packing which takes the immediate pressure off the surrounding rocks. The wooden soles are placed upon dry walls, which give more or less under the first pressures.

The iron arches are bound together by the use of small iron bars ·4 inch square, with a hook at each end. They are of such a length as to extend over three arches, and by breaking joints the whole is flexibly connected together.

This system will yield under pressures to a certain point, without deformation of its chief parts.

The costs of various sizes of this system, with iron at £5 12s. 6d. per ton, are :—

		Each.
Single way, open space 7·2 feet by 5·2 feet	Hinged arches 6 feet long, 29 pounds per yard	14s. 0d.
	16 „ „	12s. 6d.
Double way, open space 7·2 feet by 6·5 feet	Hinged arches 7·2 feet long, 29 pounds per yard	18s. 0d.
Airways, open space 4·6 feet by 5·2 feet	Hinged arches 4·6 feet long, 29 pounds per yard	11s. 0d.
Airways, open space 4·3 feet by 5·2 feet	Hinged arches 4·0 feet, 16 pounds per yard	8s. 6d.

M. W. B.

SINKING A SHAFT THROUGH QUICKSANDS BY COMPRESSED AIR.

Schachtabteufen im Schwimmsande mit Hülfe von comprimirter Luft. Zeitshcrift für das Berg- Hütten-, u. Salinen-Wesen im Preussischen Staate. Vol. XXXIII., pp. 221, 222.

The Maria Colliery near Aix-la-Chapelle has been recently sunk by means of iron tubbing and compressed air through a quicksand 121 feet thick. The air had a pressure of 3·2 atmospheres. The workmen worked eight hours in three portions, with intervals of half hours of rest, during which they came to bank. The air in the chamber had a temperature of 52° to 56° Fahr. The work was completed in 228 days, during which time the men working in the compressed air experienced no ill effects. M. W. B.

METALLIC LININGS FOR GALLERIES.

Blindage des Galeries aux Houillères de Rochebelle. By — GERRARD. *Bulletin de la Société de l'Industrie Minérale. Sér.* 2, *Vol. XV., pp.* 391-448. *Plates XXI. and XXII.*

1.—GEOLOGY.

The geological features of the Rochebelle Collieries are described.

2.—TYPES OF FRAMES.

The first frame tried consisted of two pieces of ∩ form, connected at their summit by a sleeve and wood key, the upper part being semi-circular, the straight sides resting upon iron shoes placed upon wooden soles. These frames were made of rails weighing 28 lbs. per yard. The uprights were deformed by lateral pressure, and the soles by the heaving of the bottom and pressure of the sides.

In the second type the frames were made of two pieces (united by sleeves), and are made of oval form, resting upon iron shoes, with a short wooden sole; these have stood pretty well with the exception of occasional rupture of the sole.

The third type was made of elliptic form ⬯ in two pieces, united by iron sleeves and wood keys at top and bottom. This construction was subject to unequal strains; it was of difficult construction and use, and was consequently abandoned.

The final arrangement consists of two pieces of circular shape ○, connected by iron sleeves and wood keys, either at top and bottom or at the sides. These have been very successful; they are made of iron and steel rails, varying from 28 to 44 lbs. per yard. The diameter of the circles of the framing varies from 4 to 6 feet, inside measurement.

As old rails are not always at hand of convenient lengths, they have been occasionally replaced by U and T iron, weighing 22 lbs. per yard, which are found to be as efficient as rails weighing 28 lbs.

Fishplates are unsuitable for joining the sections together, being too rigid and requiring costly screws and nuts. The sleeve and wood key make an elastic connection and is of cheap construction; it has frequently been seen that the ends hold together by friction when the sleeves are broken. The principal use of the sleeve is to hold the parts together until the pressure brings them into intimate contact.

3.—EXAMPLES OF USE OF IRON FRAMES.

Costs of various applications of iron and wood frames are compared, showing a marked saving of cost by the use of iron frames.

4.—Advantages of Iron Frames.

The most important advantage is the small space occupied by the frames. Thus, comparing three systems:—

	Total Area of Drift.	Useful Area.	Ratio.
	Sq. Ft.	Sq. Ft.	Per Cent.
Walling, 2 feet thick	77·5 ...	28·9 ...	37
Timber balks, 16 inches	73 ...	38 ...	52
Iron frames	31·4 ...	25·4 ...	80

Or, in other words, for one foot of available area of drift the area excavated will be:—For iron frames 1·23 square feet, timber 1·92 square feet, and walling 2·70 square feet. Consequently the cost of drifting will be greatly decreased if iron frames are used.

In gassy mines the iron frames offer great security against falls due to explosions. This has been shown experimentally in the drift at Neunkirchen.

5.—Maintenance of Iron Frames.

Of 2,000 iron frames in use less than 2 per cent. have been replaced.

Iron hoops have been successfully used instead of planks for backing deals. Various sections have been employed:—2·36 × ·20, 1·77 × ·08, ·79 × ·12, ·31 × ·31, and round rod ·24 inches. But no definite conclusions can yet be given as to their use.

These rods have been made about one yard long, with hooks at their ends, but it might be an advantage to make them five or six yards long. Old wire ropes might be employed for this purpose.

6.—Manufacture of Frames.

Details are given of the necessary furnaces and appliances for bending the iron to the sections of the drifts. M. W. B.

THE GEOLOGY OF EASTERN TONQUIN.

Note complémentaire sur la Géologie de l'Est du Tonkin. *By* E. Jourdy. *Bulletin de la Société Géologique de France, Vol. XIV., Série III., pp.* 445-453. *Map and Sections in the text.*

In the delta of the Song-Cau, west of Haiphong, is the so-called Elephant Mountain, consisting of huge blocks of sandstone and a mass of black carboniferous limestone (fossil bearing), with thin intercalated siliceous beds. Opposite this mountain, east of Haiphong, there is another *massif* of limestone; and the coal-field is found on the shores of the bay of Hone-Gay. The characteristic rocks are, besides the limestone, quartzite with iron and antimony ores, and shales with numerous casts of plants. These shales generally split the coal seam in two—the double seam (without the shale) being, on the whole, about 3½ yards thick. At the island of Hone-Gay it is 8 or 8½ yards thick. The coal is very shiny, it disintegrates easily, and appears to be of rather mediocre quality. It resembles somewhat anthracite; and marine engineers state that it is of no use as fuel unless it be mixed with an equal quantity of bituminous coal. Workings have been begun in an experimental way, but up to the last advices no other quality of coal had been found.

This report is followed by a detailed note by R. Zeiller, on the casts of plants found in the shales of the above-mentioned coal-field. Among them are one or two new species of ferns and cycads. (See Plates XXIV. and XXV.) L. L. B.

THE DIAMOND-BEARING PEGMATITE OF HINDUSTAN.

Note sur une Pegmatite diamantifère de l'Hindoustan. By — CHAPER. *Bulletin de la Société Géologique de France, Vol. XIV., Série III., pp.* 331-345.

The author of this report was sent to India by the French Government in 1882, and he here gives an account of his researches in the district of Bellary, in the extreme west of the Presidency of Madras. He describes briefly the geological characteristics of the country—rocks exclusively crystalline, none of recent sedimentary origin; very little humus, the arable soil being chiefly made up of the products of decomposition of the underlying rocks; springs scarce.

The chief rocks of the diamond region (Wudjar Curroor, Goondacul, Bellary) are: 1st, a dark grey hornblendic rock; 2nd, a pegmatite, consisting of orthoclase, oligoclase, quartz, and epidote, without a trace of mica or hornblende; 3rd, a metamorphic rock, consisting mainly of felspar and quartz, with muscovite or biotite; 4th, a granulite. A remarkably large vein of milky quartz is found 5 miles to the south of Wudjar Curroor in the first-named rock. Specimens of all the preceding have been placed in the collections of the Paris School of Mines and of the Collège de France.

To the east of Wudjar Curroor, chiefly after a storm, the natives go about in rocky and uncultivated places looking for diamonds. The heavier the rains, the greater chance there is of finding some precious stones in the rainwash; but, according to M. Chaper, even when the search thus made is successful, the measure of success is so small as hardly to repay the amount of time consumed in it.

The natives stated that they generally found precious stones in the pegmatite and metamorphic rock. Chaper had diggings made at different points in these rocks, and he found two diamonds, two sapphires, and three rubies, and this before washing and sorting the material. Nothing was found after washing and sorting. The diamond is crystallised in octahedra; its faces are less smooth, and its intersection angles less sharp than those of the Griqualand West diamond. It is accompanied by corundum of various shades of blue and red, but having no crystalline form. None of the other minerals usually found with diamond (rutile, garnet, zircon, sahlite, hematite, etc.) have here been traced.

The author discusses the question of possible fraud, but dismisses, as highly improbable, the supposition that the precious stones, found by his colleagues and himself, had been previously placed in the disintegrated rock by some person or persons unknown. He admits, however, that, under the circumstances, fraud would not have been easily detected. No encouragement can be found in his report for the expenditure of capital or labour on "diamond diggings" in the above-named district.

L. L. B.

THE SILVER MINES AT MARIENBERG.

Der Amandus Flache im Grubenfelde der Marienberger Silberbergbau-Gesellschaft. By R. WENGLER. *Jahrbuch für das Berg- und Hüttenwesen im Königreiche Sachsen*, 1886, *pp.* 93–113. *Plates IV. and V.*

The report is preceded by a brief historical sketch of the workings known as the Amandus Flache. They occupy an undulating plateau 3,000 feet above the sea-level, dipping N.N.W. The chief constituent rocks of the district belong to the gneiss formation, with here and there outbursts of syenite and diorite. Briefly, the mineralogical composition of the above rocks may be described as follows:—

Gneiss.—Quartz, in light grey irregular granules; felspar, generally orthoclase, varying from white to grey and light flesh-colour. Plagioclase is also found often enough. Mica, very dark biotite and silver-white muscovite. Tourmaline and rutile not yet found.

Syenites—Generally light grey in general tint; consist of orthoclase, decomposed light green hornblende, mostly decomposed biotite, and quartz porphyritically dispersed through the mass in small quantities. Apatite, microcline, augite, and ilmenite are sometimes found as accessory minerals.

The general strike of the Amandus Flache is S.E. to N.W., and cuts the gneiss at a horizontal angle of 63°. There is no essential disturbance to note, as the workable lode is rarely faulted by more than its own thickness. General dip, 65° N.E. Thickness of the metalliferous deposit varies from 4 inches to 10 feet, and the proportions do not seem to change as the workings are pushed deeper (1,070 feet in the direction of the dip). The vein stuff consists mainly of heavy spar and decomposed gneiss. Where veins cross each other, silver ores and, in a subsidiary way, cobalt and nickel ores are found. These latter become, however, very prominent at certain points. Well-formed crystals are rarely observed.

On this follows a detailed description of the chief minerals constituting the ores and vein stuff. Their chronological order is thus tabulated:—

I.—Hornstone, quartz, agate } Occur also together.
II.—Amethyst, red heavy spar, blue fluorspar }
III.—White heavy spar, dolomite, blue fluorspar, yellow fluorspar, lead glance, pyrargyrite, iron pyrites, smaltite.
IV.—Ankerite, chalybite (arsenical), pyrargyrite, iron pyrites, polybasite, marcasite, calcspar, lead glance, lautite.
V.—Calcspar, chalybite, argentite, arsenic silver, acanthite.
VI.—Copper pyrites, xanthocone, thraulite.
VII.—Cobalt and nickel ore, ferrous sulphate, calc sinter, iron sinter, silver ore.

But the minerals were in many places so irregularly mingled that their chronology could not be safely determined.

The percentage of the yield, and various local circumstances are then discussed at some length. The workings have been giving less favourable results year by year since 1880, and the falling off would have been more conspicuous but for the application of improved methods of extraction. A table is appended with statistics from 1836 to 1884 inclusive. L. L. B.

THE METALLIFEROUS DEPOSITS OF THE WESTERN PYRENEES.

Note préliminaire sur les gisements métallifères des Pyrénées occidentales. By P. W. Stuart-Menteath. *Bulletin de la Société Géologique de France, Vol. XIV., Série III., pp.* 587-607.

The author discusses in some detail the general geological constitution of the district. He states that to the north of St. Jean Pied de Port he found several plant remains of the Coal-Measures, and he refers certain conglomerates to Permian age.

The district of Haya is remarkable for lead containing silver; the district of Aldudes is rich in copper with silver; dolomitic limestones passing into quartzite, and both impregnated with copper, are frequent in the last-named region. The general direction of the lodes is, in the first case, N.W. to N.E., in the second case E.N.E. to N.N.W. The iron ores in the rocks of Haya follow, as a rule, a N. to S. line; and in the rocks of Aldudes a N.N.W. line. The few exceptions noticed are attributable to local causes, which are indeed found to influence considerably in some cases the direction of the lodes.

The author states that the empirical rule, enunciated by him in 1881, that a faulted fragment of Trias amid Palæozoic rocks was in this region a good guide to productive lodes, has been confirmed by further observation. L. L. B.

MINING PRODUCE OF THE DISTRICT OF DORTMUND (HANOVER, WESTPHALIA, AND RHENISH PRUSSIA) IN 1886.

Produktions-Übersicht der im Oberbergamtsbezirk Dortmund im Jahre 1885, in Betrieb gewesenen Bergwerke und Salinen. Glückauf, No. 14, 1887.

A.—Coal Mines.

District.	No. of Collieries.	Produce in Tons.	Persons Employed.
1.—Osnabrück	7	119,056	909
2.—Hamm	5	613,472	2,289
3.—Dortmund, East	13	1,764,895	7,141
4.— Do. West	15	2,163,270	8,655
5.—Witten	9	1,622,147	5,767
6.—Sprockhövel	25	514,698	2,171
7.—Dahlhausen	15	1,905,666	7,326
8.—Bochum	11	2,817,223	9,414
9.—Herne	7	2,168,417	7,349
10.—Recklinghausen	10	2,044,612	6,842
11.—Gelsenkirchen	9	3,221,358	10,758
12.—Essen	8	2,725,595	8,145
13.—Frohnhausen	11	2,379,091	7,418
14.—Oberhausen	15	2,904,669	9,783
15.—Altendorf	16	1,020,421	3,418
16.—Werden	10	352,222	1,279
Private mines in 1886	186	28,336,812	98,664
Government mines in 1886 ...	2	160,505	1,123
Grand total of 1886	188	28,497,317	99,787
Do. 1885	197	28,970,323	101,829

B.—Iron Ore Mines.

District.	No. of Mines.	Produce in Tons.	Persons Employed.
1.—Osnabrück	9	192,483	785
3.—Dortmund, East	4	144,477	516
6.—Sprockhövel	3	48,638	239
7.—Dahlhausen	1	167,460	682
15.—Altendorf	1	1,097	20
16.—Werden	1	7,682	36
Total of 1886	19	561,837	2,278
Do. 1885	20	551,778	2,230

C.—Zinc Ore Mines.

District.	No. of Mines.	Produce in Tons.	Persons Employed.
5.—Witten	1	21,769	529
6.—Sprockhövel	2	1,332	17
16.—Werden	2	11,136	485
Total of 1886	5	34,237	1,031
Do. 1885	5	33,140	1,024

D.—Lead Ore Mines.

District.	No. of Mines.	Produce in Tons.	Persons Employed.
5.—Witten	2	109	8
16.—Werden	2	930	104
Total of 1886	4	1,039	112
Do. 1885	4	1,091	105

E.—Copperas Mines.

District.	No. of Mines.	Produce in Tons.	Persons Employed.
1.—Osnabrück	1	243	2
4.—Dortmund, West	2	770	7
6.—Sprockhövel	1	13,732	72
16.—Werden	1	84	1
Total of 1886	5	14,829	82
Do. 1885	3	19,252	114

F.—Salt Works.

District.	No. of Works.	Produce in Tons.	Persons Employed.
1.—Osnabrück	2	1,245	36
2.—Hamm	3	18,485	195
Private works in 1886	5	19,730	231
Government works in 1886 ...	1	1,418	25
Grand total in 1886	6	21,148	256
Do. 1885	6	19,904	243

M. W. B.

THE ZINC BLENDES OF FREIBERG.

Über den Zinngehalt und über die chemische Zusammensetzung der schwarzen Zinkblende von Freiberg. *By* A. W. Stelzner and A. Schertel. *Jahrbuch für das Berg- und Hüttenwesen im Königreiche Sachsen*, 1886, *pp.* 52-70. *One Plate in the text.*

The chief object of the researches narrated in the above report seems to have been the determination of the average amount of tin compounds known to exist in the zinc blendes of Freiberg. Specimens were taken from eight different workings and submitted to mineralogical and chemical analysis. Results may be summarised as follows—Percentage composition—Zinc 50 per cent., iron 13 per cent., sulphur 33 per cent., tin (soluble) 0·35 per cent. The tin was present in the form of sulphides and oxides; manganese, copper, and cadmium were found in slightly larger proportions, as also slight traces of silver. One specimen contained 1¼ per cent. lead and 0·7 per cent. silver. The authors compare the Freiberg blende to the Cornwall christophite analysed by J. H. Collins.

A few crystallographical details are then given, and it is observed that the tin ore, which is almost always found mechanically mixed with the blende, is sometimes embedded directly in the latter, sometimes in the quartz of the lode. L. L. B.

A NEW SILVER ORE.

Über die Entdeckung eines neuen Silbererzes (Argyrodit) bei Himmelsfürst Fundgrube bei Freiberg. *By* E. W. NEUBERT. Also *Mineralogische Mittheilungen.* *By* A. WEISBACH. *Jahrbuch für das Berg- und Hüttenwesen im Königreiche Sachsen,* 1886, *pp.* 84–85, 89–92. *Plate III., and a drawing in the text.*

In September, 1885, a new ore, which received the name of argyrodite, was discovered in the Himmelsfürst mine near Freiberg. Chemical analysis gave the following results:—Silver 75 per cent., germanium 7 per cent., sulphur 17 per cent., traces of iron and zinc.

Germanium is supposed to be a new element, possessing properties akin to those of arsenic and antimony. Argyrodite has metallic lustre, is of a steel grey colour on its crystalline surfaces, but on fractured surfaces of a purplish violet hue; streak, dark silver grey: opaque, hardness 2½; specific gravity 6; crystals very small, monoclinic system, often twinned. When sublimed it appears as a shining black substance, closely resembling cinnabar. The ore was specially tested for bismuth, but none was found. At the time of the manager's report, the lode extended only over 45 feet, thickness varying from 2 to 15 inches. L. L. B.

THE ELEMENT "GERMANIUM."

Mittheilungen über das neue Element "Germanium." *By* CL. WINKLER. *Jahrbuch für das Berg- und Hüttenwesen im Königreiche Sachsen,* 1886, *pp.* 163-166.

The discoverer of the new element, and author of this report, thinks that in "Germanium" he has found the missing element "Ekasilicium," whose existence was predicted by Mendelejeff in 1872. The great similarity between one of the germanium sulphides and antimony sulphide had at first led to the conclusion that both germanium and antimony were to be classed in the same group, but the author now speaks of classing it as a tetratomic element with silicium, titanium, and tin.

Two oxides of germanium are supposed to exist; one only has as yet been determined with certainty; two sulphides—an iodide and a chloride—are formed by its combination with the corresponding elements. On reduction it separates out in small grey octahedric crystals. Experiments were yet proceeding at the time of the report.

L. L. B.

EXPERIMENTS UPON THE IGNITION OF COAL GAS AND FIRE-DAMP BY SPARKS.

(1) *Versuche über die Entzündlichkeit der Grubengase durch Funken, welche bei Bearbeitung harter Gesteine mit Stahlwerkzeugen, eventuell durch Reibung solcher Gesteine an einander entstehen.* *By* JOHANN MAYER. *Oesterreichische Zeitschrift für Berg- und Hüttenwesen, Vol. XXXIV.*, 1886, *pp.* 379–382, 398–401.

This paper contains a summary of experiments made to ascertain the conditions under which fire-damp may be ignited by sparks produced by steel tools used in mining hard rocks, or by the friction of hard rocks.

(*a*) The sparks produced by steel tools were similarly produced by the use of a grindstone of coal-measures sandstone, 15·7 inches diameter and 3·1 inches thick, running at

250 to 300 revolutions per minute, against whose periphery two or four pieces of pointed steel were placed, with a pressure of 8·8 to 13·2 lbs. A continuous stream of sparks was produced of varying intensity. The ignition was produced by forcing a current of coal gas or fire-damp against the sparks, or by producing them in an explosive mixture.

The report of the French Fire-damp Commission gives the temperatures of ignition of the following gases:—

	Degs. Fahr.
Heavy carburetted hydrogen, C_2H_6	1,022
Hydrogen, H	1,076
Carbonic oxide, CO	1,202
Marsh gas, CH_4	1,436

The report of the Prussian Commission gives a much higher temperature of ignition for fire-damp, as silver and copper wires were fused without igniting it.

The experiments were made with coal gas and with mine gas of the following composition:—

Marsh gas, CH_4	96·00
Carbonic acid gas, CO_2	1·10
Oxygen, O	·10
Other gases, N	2·80

When the stone was dry ordinary coal gas was regularly ignited after the grindstone had made a few revolutions. With a sprinkling of water on the stone the sparks were less numerous, but the coal gas was fired four times in half an hour's trial of the grindstone.

It was found to be exceedingly difficult to ignite fire-damp, and only one ignition was produced during the long series of experiments, and it is probable that the use of water would entirely obviate the danger.

(*b*) The pieces of steel used in the first experiments were replaced by hard sandstones, some of which were the same as that of the grindstone, and the pressure was increased to 22 lbs. Ordinary coal gas could be ignited after the grindstone had made a few revolutions with a piece of hard sandstone pressed against it. When shale was pressed against the grindstone the ignition was produced with difficulty. When shale was pressed upon a shale grindstone no sparks were produced. When fire-damp was employed it was regularly ignited, when both of the stones were of sandstone, with a pressure of 22 lbs. The ignition did not take place so quickly as when coal gas was used, in some cases only after 10 to 15 seconds elapsed.

Instances are quoted where heavy falls of stone were accompanied by an intense flash of light, which suggests the conclusion that fire-damp may be occasionally ignited by such means.

(2) *Ueber Feuerscheinungen beim Verbruche von Abbauen.* *By* JULIUS VON SPRINGER. *Oesterreichische Zeitschrift für Berg- und Huttenwesen, Vol. XXXIV.*, 1886, *p.* 469.

In order to cause a fall of roof in the Liebe-Gottes Colliery, near Zbeschau, twenty-six dynamite cartridges were used to remove the standing props, all lights were blown out, and the three men in charge observed that the fall of roof was accompanied by an intense flash of light, no sparks being seen. It may be noted that the operation was carried out at a depth of 870 feet, in a thick seam, lying at an angle of 45 degrees. The roof was of hard sandstone, and no gas was present in the district.

M.W.B.

CAMBESSÉDÈS MINING SAFETY LAMP.

Lampe de Sûreté Cambessédès. By — CAMBESSÉDÈS. *Comptes-Rendus mensuels de Société de l'Industrie Minérale, pp.* 26-31 *and Plate IV., February,* 1887.

The principle developed in this lamp is that of a central supply of air. It consists essentially of a Marsaut lamp, save that the air is only admitted through tubular pillars to an annular space in the bottom of the lamp, whence it passes through a central cone to the flame of an argand form of burner. The oil is contained in an attached reservoir, the supply being regulated by a Marriotte tube, placed a short distance below the level of the flame.

It consumes half the oil and produces four or five times more light than an ordinary lamp; it is capable of yielding a light equal to seven or eight ordinary safety lamps when required, and produces a light of uniform intensity during the course of many hours.

M. W. B.

SAFETY MINING LAMPS.

Lampes de sûreté et grisou. By — DE CASTELNAU. *Ibid., page* 73, *March,* 1887.

An overman, whose lamp had been accidentally extinguished, used one of the workmen's lamps to test for gas. This lamp, which was of the ordinary Marsaut type, fired the gas and burnt the experimenter. On examination after the accident it was found that one of the internal gauzes had been omitted.

A Marsaut lamp with a single gauze may be compared to a bonnetted Clanny, which is very safe in testing for gas in still atmospheres.

By trials it was found that the defect was due to a play of about $\frac{1}{10}$ inch when the internal gauze was absent.

It is therefore important that safety lamps must be carefully constructed, so as to ensure the close and perfect adjustment of the various parts when screwed together; and the examination of the lamps should be performed under experienced supervision, so as to prevent the misplacement or omission of any of the parts.

M. W. B.

INFLUENCE OF SEISMIC MOVEMENTS UPON THE EVOLUTION OF GAS.

Influence des mouvements Sismiques sur les Dégagements de Grisou. By — CLERMONT. *Ibid., pp.* 34-37.

It is known that earthquakes accompanied by earth motions, occasionally produce abundant escapes of gas at the surface, modifications of the course of subterranean streams, etc., and it is highly probable that a reservoir of gas in the immediate vicinity of these occurrences may be similarly effected by the fissures accompanying such motions.

But this is not the complete question; it is to enquire if the micro-seismic motions, the minute pulsations of our planet, which leave no visible traces and whose effects

are only discovered by very sensitive forms of apparatus, are related in any way with abnormal issues of fire-damp.

The writer then proceeds to recite the experiments now being prosecuted by the French Government.*

It is evident on observing figure 2, Plate VI., that the proportions of fire-damp contained in the air of the mine and the variations of the proportions are very small. The greatest does not exceed 1 per cent., the least is not under ½ per cent., and all the variations are between these limits.

It is apparent therefore that observations of this description can only yield sure results after great difficulties have been overcome, and it is scarcely probable that seismic movements have any influence upon abnormal issues of fire-damp.

The results are difficult to observe at first, as it must be admitted that an extensive mine, part in course of working and part abandoned, is always in an explosive state at one or more points, the spark being alone wanted.

Falls of roof occur at frequent intervals, and may connect these centres with the working places, without the aid of seismic movements, and produce abnormal proportions of fire-damp.

Again, in order that issues of gas may be produced by terrestrial forces, these forces must be so violent as to produce fissures in the roof or floor of the seams, and it is not apparent, without falls, that simple undulations can produce them.

It is known that earthquakes diminish in intensity with depth, and are unfelt in the interior of mines, and also that the imperfect pack walls used in longwall workings stop fractures and protect the workmen. It must be necessary therefore to have a true earthquake to produce fissures in the mass of the earth.

Fortunately these phenomena rarely occur, and their first effects would be to render the mines inaccessible, owing to the heavy falls which would be produced.

M. W. B.

THE SONORA EARTHQUAKE (U.S.).

By G. E. Goodfellow. *Science, May 20th*, 1887, *pp.* 483–4.

A series of earthquakes occurred at Tombstone, A.T., on May 3rd, 1887, beginning at 3·06 p.m., local time. No damage was done, but water gushed from the beds of old streams, which were located under U.S. water laws within one hour. Boulders were rolled down the hills. The railroad track of the Atchison, Topeka, and Santa Fé Road was bent 4½ inches out of line for a length of 300 feet. Men working at a depth of 600 feet felt the vibrations very strongly; some said they were made sick, and all said that the bottom of the shafts or drifts seemed to rise. Men working at 150 feet did not notice it very much, and some did not feel it. No damage was, however, done in the mines, the deepest workings being about 700 feet.

At Sonora and the Fronteras Valley, in Mexico, the first shock was felt at 3 p.m. on May 3rd. Several houses were thrown down, and fissures varying in width from a few inches to 10 feet, running north and south, were formed over the entire length of the valley.

M. W. B.

* See Transactions, pages 43, 44.

WATER CARTRIDGE.

Patented in Germany by MESSRS. RICHARD AND CHARLES STEINAU, *of Brunswick. D.R.P., No.* 38,000, *May 16th*, 1886.

This cartridge consists of a glass bottle filled with water and containing a glass flask of sulphuric acid which is inserted into a perforated sheet-iron case filled with quick-lime. This is dipped in water, placed in the shot-hole, and stemmed in the ordinary way. The fractures of the rocks should ensue after the moistened lime, water, and acid become heated, the flask broken, and a higher heat produced, converting the water into steam. M. W. B.

SOTTIAUX'S COAL-CRUSHER-CLEANER.

Broyeur-Épurateur. By A. SOTTIAUX. *Publications de la Société des Ingénieurs sortis de l'École provinciale d'Industrie et des Mines du Hainaut. Sér.* 2, *Vol. XVII., pp.* 133–136.

A description of this machine appears on pages 68 and 69 of Abstracts in Volume XXXV.

The results of the working of several of the machines are as follow :—

They crush the materials in proportion to their friability, and separate the useful coal from the sterile matter.

Coal treated by these machines produces 1·73 per cent. more coke than the ordinary crushed coal; and the coke is in addition more homogeneous, denser, and better and more merchantable.

The loss of coal, passed away with the sterile materials, is, for some coals, about 5 lbs. per ton treated.

The quantity of stones removed varies with the purity of the coal and the difference of friability of the materials treated. 5 per cent. has been removed from coal containing 12 per cent. of stone.

The power of the apparatus is very great, as it can treat 50 tons of coal per hour ordinarily it treats about 35 tons per hour, with a motor of about 15 horse-power.

A washer for treating the same quantity of coal would cost about £4,000, and the loss of coal would vary from 8 to 30 per cent. or more.

Under ordinary conditions, one of these machines, to treat 300 tons per 10 hours, would cost about £200.

The machine cleans and pulverises the coal irrespective of the amount of moisture.

The apparatus requires little or no attention, and receives pieces of wood, iron, etc., without damage to itself. M. W. B.

SAFETY CATCH FOR TUBS RUNNING UPON INCLINED PLANES.

Parachute pour plans inclinés. By A. LISBET. *Publications de la Société des Ingénieurs sortis de l'École provinciale d'Industrie et des Mines du Hainaut. Sér.* 2, *Vol. XVII., p.* 132. *Plate XIII.*

This catch consists of a plate with a pair of bent claws projecting from one end. It is fitted with two holes, one of which carries a hook to attach to the tub and the safety chain attached to the top of the tub. The rope is attached to the other hole.

As soon as the rope breaks, the claws (which are held up by the tension of the rope) fall to the ground and fasten themselves to the sleepers. M. W. B.

USE OF MINERAL OILS FOR FUEL.

Emploi des huiles minérales comme combustible. Compte Rendus de la Société des Ingenieurs Civils. 1886, *Vol. II., p.* 231.

The following are the results of experiments upon the evaporating power of various oils:—

	Water at 100°.
Petroleum, at the Brooklyn Arsenal, 1886	13·44
„ Woolwich Arsenal, 1866–7	13·66
Creosote—Sadler, in 1885	13·00
Fish oil—Scotland, in 1885	15·50
Astatki, Fraissinet Co., on land, in 1885	15·29
„ „ on S.S. "Aude," in 1885 ...	14·10
„ Grazi-Tzaritzin Railway, in 1884	14·00

M. W. B.

THE ALEXANDRE FAN.

Du Ventilateur a force centrifuge considéré comme ventilateur a réaction. By Louis Thibaut. *Publications de la Société des Ingénieurs sortis de l'École provinciale d'Industrie et des Mines du Hainaut. Sér.* 2, *Vol. XVIII., pp.* 43–71.

The writer gives a critical review of the conditions to be observed in reducing as much as possible the power remaining in the air on leaving a fan.

The Alexandre centrifugal fan has curved blades, with the following special features:—The exit channels are turned opposite to the direction of rotation of the fan, and the re-entries of air are considerably diminished, if not completely suppressed, by the arrangement of the tips of the blades. The blades are broken off at about 12 inches from the external circumference, where they are duplicated, and their tips are rapidly bent towards the circumference. This arrangement appears to greatly reduce the volume of re-entering air.

The following experiments have been made upon one of these fans 78¾ inches in diameter:—

No. of Experiments.	Revolutions per Minute.		Water-gauge.	Volume of Air per Minute.	Horse-power in Air.	Indicated Horse-power.	Useful Effect.
	Engine.	Fan.					
			Inches.	Cub. Ft.			Per Cent.
1	46½	139	·512	5,040	·406	·817	49·7
2	65	195	·945	7,100	1·055	1·942	54·3

The following experiments were made at various velocities:—

Revolutions.	Water-gauge Observed. Inches.
139	·512
180	·772
195	·945
339	2·362

M. W. B.

UTILISATION OF FIRE-DAMP.

Captage et Utilisation du Grisou. By — HILT. *Comptes-Rendus Mensuels de la Société de l'Industrie Minérale*, 1886, *pp.* 100–102.

The inquiries of the Prussian Fire-damp Commission have proved two important points, upon which our installation was based.

The exact determination of the time required for the diffusion of fire-damp with common air. It was found that if a volume of fire-damp was passed by the floor into a gallery, the same volume was afterwards found at the roof, and only gradually mixed with the atmospheric air. When 36 cubic feet of gas were placed in a chamber of 360 cubic feet, nearly the whole of the gas was found in about an hour at the top, and complete diffusion only took place after more than three or four hours.

It is different when the air is in motion; but as the velocity of the air in the working places is not great, it appeared possible to find the greater portion of the gas near the roof and not mixed with air.

The second point is that gas is almost solely produced from freshly-wrought coal, or from recently-exposed coal surfaces; that the issue occurs in the first few hours, and ceases at the end of a few days. Consequently the largest volume of gas is found at the working faces, and, except for blowers, the old workings contain very little gas.

The plant for the capture of the gas would comprehend a series of pipes going into the face of all the working places, connected with a main leading to a powerful exhausting machine upon the surface.

A favourable opportunity for the economical realisation of our ideas occurred at the Kœnig Colliery, where a large air-compressing engine was lying idle. The compressors were converted into exhausting machines, and the requisite pipes were laid into the working places in a district opened out a few years previously.

The district had an output of 100 tons per day, with less than 100 workmen, and from 21 to 28 cubic feet of fire-damp per minute were exhausted, forming with the air a mixture containing 6 to 8 per cent. of gas. The air current of the district only contained $\frac{1}{4}$ per cent. of gas.

The mixture exhausted did not vary greatly in its composition during the day: the safety lamp showed that it was explosive. Two analyses were made daily.

The experiments had no influence upon the ventilation of the district or of the mine. The district was ventilated by 7,000 to 7,800 cubic feet of air per minute. Part of the gas was carried away by the air, but the exhausted mixture accounted for 60 per cent. of the gas given off. The machine exhausted 360 cubic feet at atmospheric pressure per minute, and as it was only working at about one-fourth of its power, it would be possible to obtain 90 to 100 cubic feet of gas per minute.

A gaseous mixture containing 9 to 10 per cent. of gas is explosive, and before burning it means must be adopted to prevent the explosion extending into the pipes or gasometers. The gasometers should be isolated by hydraulic locks, and wire gauzes should be placed in the pipes.

The gaseous mixture was applied to two boilers, and 15 lbs. of water were evaporated per lb. of gas, supposing that the mixture contained 8 to 10 per cent. If all the gas in the mine had been collected there would have been 650 cubic feet per minute, which would have evaporated 350,000 lbs. of water per 24 hours.

The explosive mixture would be most suitable for gas engines, more especially as it burns without smell. With gas at 2s. 4d. per thousand feet, the captured gas equal to about 580,000 cubic feet per day would be worth £67 13s. 4d., or £24,000 per annum.

Even if these figures are exaggerated it seems possible that the dangerous enemy may be made a source of revenue. M. W. B.

RELATIVE POWER OF EXPLOSIVES.

Puissance relative des Substances Explosives. *By* — BERTHOLET. *Revue Industrielle, November*, 1886.

The following table shows, in column *a*, the quantity of heat produced by the combustion of a gramme of the substance; and *b*, the volume in litres of the gaseous products of combustion. It is assumed that the explosive force may be represented, approximately, by the products of the numbers in columns *a* and *b*, which are shown in column *c*.

Explosives.	Heat Produced. (*a*.)	Volume of Gas. (*b*.)	Explosive Force. (*c*.)
Mining powder	509	·173	88
Military powder	608	·225	137
Sporting powder	641	·216	139
Powder (nitrate of soda)	764	·238	190
Powder (chlorate of potash)	972	·318	309
Gun-cotton	590	·801	472
Picric acid	687	·780	536
Picrate of potash	578	·585	337
Gun-cotton, mixed with chlorate of potash	1,420	·484	680
Picric acid „ „	1,424	·408	582
Picrate of potash „ „	1,422	·347	478
Nitro-glycerine	1,320	·710	939

Nitro-glycerine is evidently the most explosive. Theoretically, only one substance can exceed it, protoxides of nitrogen, liquefied or mixed with carburetted fluids, but it is difficult to use. M. W. B.

THE IRON MINES OF BILBAO.

Mines de Fer de Bilbao: Résumé historique de l'Industrie sidérurgique dans les Provinces Basques. *By* ALEXANDRE POURCEL. *Le Génie Civil, Vol. XI., pp.* 70–74.

The iron ores of Cantabria, and especially those of Somorrostro, near to Bilbao, have been worked from the earliest times. Native historians allege that they were mined by Tubal, the grandson of Noah. Pliny no doubt referred to the Triano deposit, when he described a mountain upon the sea coast as formed of an immense block of iron ore.

No local record is found until the beginning of the sixteenth century, when the historians relate that in the tenth century the valuable *vena dulce* was exported from Bilbao to French and Spanish ports. At the same time *iron* was exported to England, France, and the Netherlands.

Traces of *ferrerias* (hearths), slag heaps, etc., bear witness to the old iron industry of Bilbao. These rudimentary methods were succeeded at an early date by the more economical Catalan system. This process is described in "Grandesas y cosas notables de España," written by Don Pedro de Medine in 1595, and shows that it has continued with slight variations up to the present day. This writer says that there were at that period in Biscay and Guipuzcoa 300 ferrerias, each producing about 1,000 cwts. of iron and steel per annum, a total of less than 15,000 tons. Of this quantity one-third was used in naval construction, one-third was used in the construction of fire-arms, tools, nails, and agricultural implements, and the remaining third part was exported as bar iron.

In 1658 the finished products were about 5,000 tons. In the eighteenth century Biscay alone produced 12,000 tons from 245 furnaces.

The only ore used at these ferrerias of the Basque provinces was the *vena dulce*, a red hematite almost free from gangue, tender, oily to the touch, and easily mined. It is not found in pockets, but in veins crossing the *vena dura* or campanil, and more abundantly (encased in clay) in the large deposits of *rubio*.

The iron produced from *vena dulce* is free from every impurity; it is very tenacious, malleable, and easily converted into steel by cementation. The reputation of the iron is immortalised by Shakespeare in the term *Bilbo*, so frequently applied by him in his plays to lethal weapons forged from Spanish iron.

The most celebrated forges were situate at Guipuzcoa. Thus in 1785 there were eighteen anchor manufactories. About the same time there were 154 ferrerias at work in the lordship of Bilbao, producing 7,300 tons of iron per annum.

In the early part of the nineteenth century the industry began to decay, owing to foreign competition, although protected by prohibitive decrees, until it did not exceed 4,000 tons per annum. It fell during civil wars to 1,000 tons, and from 1840 to 1859 it only averaged 3,200 tons per annum.

The supply of ore to the ferrerias seems scarcely to have touched the enormous deposits until the large iron works of Europe commenced to draw supplies from them. In the beginning of the present century the output was about 40,000 tons per annum, which might be exceeded when the production of iron in Biscay alone was 12,000 tons.

The first blast furnace was erected in 1848 at Santa Ana de Bolueta, near Bilbao. The old ferrerias fought a hard fight for many years against the indirect process for the manufacture of wrought iron, and at the present time the produce of the ferrerias is profitably applied in the manufacture of horse shoes, nails, culinary and other domestic utensils.

In 1854 the Ibarra Brothers erected at their Baracaldo works a Chenot furnace for the production of spongy iron. The experiments gave satisfactory results, and in 1859 there were eight furnaces at the Baracoldo works, which produced, up to 1871, 32,000 tons of spongy iron, equal to about 18,000 tons of finished iron. The process was abandoned in 1876.

The Tourangin process was adopted in 1860 at the Gastaca and six other works. This reducing furnace is a kind of stückofen or vertical blast furnace, producing spongy iron like the Chenot, but of cheaper construction and simpler working. The process has been improved by Don José Juan Juarégui, and is employed at his works for the manufacture of soft iron. Four of these furnaces yielded 1,850 tons of finished iron in 1883, and the gross produce by this system from 1860 to 1883 has been 46,750 tons.

The Ibarra Brothers erected a second blast furnace at the Guriezo works in 1849, and at the same time the Santa Ana works erected refineries to treat their own pig iron and to attempt the manufacture of iron equal to that of the Catalan process. These refineries were stopped prior to the erection of another blast furnace in 1854. A third blast furnace was erected at the Santa Ana works in 1860, and gave a short trial to the Tourangin process. They adopted the Siemens-Langlade process in 1873, and produced iron similar to that produced by the direct processes.

The first coke furnace and puddling furnaces were erected by the Ibarra Brothers at Baracaldo works in 1858. This furnace had a capacity of 3,500 cubic feet, and was blown with hot blast. A second coke furnace was blown in in 1878, and had a capacity of 5,700 cubic feet, but was not provided with regenerative hot-blast stores. At this time the output of the Ibarra Brothers' works would be about 30,000 tons of coke pig iron, 10,000 to 12,000 tons of rails, etc., and 600 to 800 tons of castings per annum.

In 1882, a limited company, the Sociedad de Altos Hornos y fabricas de hierro y acero de Bilbao, took over the business of the Ibarro Hermano y C^{a}, with the intention of erecting steel works and rolling mills, served by two large blast furnaces. These blast furnaces were started in 1885. The steel works contain two converters, two large cupolas, three small cupolas for fusion of spiegel, two reheating furnaces on the Bochum system, into which the ingots are placed when the moulds are removed, a furnace for reheating blooms, a large reversible cogging mill with hot shears, and a roughing and finishing mill, driven by the same engine. The converters make 13 to 15 charges per 12 hours, or from 112 to 125 tons of blooms. The mills are capable of producing about one-third more when rolling 60 pound rails, without intermediate heating.

The San Bartolemé works at Miravalles have a blast furnace, puddling forge, and a balling furnace upon the Langlade system, and produced 1,200 tons of merchant iron in 1884.

The San Juan works at Usansola, now abandoned, produced a similar quantity from one charcoal furnace, three puddling furnaces, and one balling furnace.

The Santa Agueda works sold 1,700 tons in 1884, and the four puddling furnaces are treating pig iron from the San Francisco blast furnaces.

In the province of Guipuzcoa, the San Martin works near Beasain were erected in 1866, with a rolling mill and two balling furnaces, and produce 3,000 tons yearly. Two of Langlade's puddling furnaces were erected in 1880–1, and a balling furnace in 1883.

The charcoal blast furnace at the San Pedro works, near Elgoibar, was blown in about three years ago, with a daily production of about 12 tons.

The Galindo works were started in 1882, and comprise four blast furnaces, furnished with twelve Whitwell stoves, producing from 220 to 240 tons of pig iron per 24 hours upon a consumption of 19 to 20 cwts. of coke.

The Viscaya Company, with a capital of £500,000, was established in 1883, to rival, at the very least, the celebrated Cockerill works in Belgium. At present the plant is limited to two blast furnaces.

The three large modern works (Altos Hornos, San Francisco, and Viscaya) can produce about 225,000 tons of pig per annum, of which two-thirds would be available for exportation. In 1886 the exports were 57,999 tons, and the coast and railway sale was 42,629 tons.

These furnaces should compete with English hematite furnaces; in fact, the Durham coke (6 to 9 per cent. of ash) is delivered at the furnaces at 19s. per ton, and the ores, which yield more than 50 per cent., seldom cost more than 5s. 6d. Limestone (free from phosphorus) costs 2s. 9d. to 3s. 3d. per ton. With these data, and with labour averaging 3s. per ton, the cost cannot exceed 40s., and will probably be from 35s. to 38s. per ton.

The production of the Bilbao mines for some recent years has been:—

Year.	Tons.	Year.	Tons.	Year.	Tons.
1860 ...	69,816	1869 ...	164,800	1878 ...	1,305,656
1861 ...	54,869	1870 ...	250,337	1879 ...	1,262,671
1862 ...	70,460	1871 ...	403,142	1880 ...	2,683,627
1863 ...	70,720	1872 ...	402,000	1881 ...	2,620,626
1864 ...	120,470	1873 ...	365,340	1882 ...	3,855,000
1865 ...	132,360	1874 ...	10,821	1883 ...	3,627,752
1866 ...	89,912	1875 ...	34,296	1884 ...	3,216,321
1867 ...	136,075	1876 ...	432,418	1885 ...	3,311,419
1868 ...	154,120	1877 ...	1,040,264	1886 ...	3,185,228

The production of ore has decreased since 1882, and at the same time the mines in the hands of private owners are being gradually exhausted. It would be possible to produce 4,000,000 tons in 1888 and 1889, but the output would be afterwards reduced to 3,000,000 tons, which could not be maintained for more than a further four or five years.

The two principal mining companies of the district, the Orconera Iron Ore Company and the Société Franco-Belge des Mines de Fer de Somorrostro, have determined to limit their output, the first to 800,000 tons and the second to 350,000 tons per annum. This foresight assures the output of the Orconera Company for 20 years and the Frano-Belge Company for 25 years, and an assured output of 1,150,000 tons for 20 or 25 years for the works interested, viz., the Altos Hornos, Consett, Dowlais, and Krupp in the one, and the Altos Hornos, Denain, Montataire, and Seraing in the other.

The Luchana Mining Company has 1,000,000 tons in reserve.

Senor Martinez de Las Rivas requires for his San Francisco works 150,000 tons out of the 320,000 tons raised from his chief mines, La Union and Amistosa, which still contain more than 6,000,000 tons, whilst his other royalties are nearly exhausted.

The Viscaya Company is supplied from the Galdames mines, and will leave their own royalties at Ollargan untouched until the last moment.

It is very probable, therefore, that after 1891 the supply of ore available for the market will be greatly reduced, and the annual output will fall in less than ten years to about 2,000,000 tons. The result will probably be a rise of prices, should the present demand continue, and it is possible that some of the mines of the Pyrenees near to the sea or the Mediterranean may be re-opened. M. W. B.

THE SILVER MINES OF ORURO IN BOLIVIA.

Ueber die Silberminen von Oruro in Bolivia. A. Webner. *Berg- und Huettenmænnische Zeitung, Vol. XLVI., p* 157.

The Cerro de San Cristóbal, near Oruro, standing about 13,000 feet above sea-level, has been known since the times of the Incas for its rich silver mines. For several years the Bolivian mines have been the prey of bubble companies, and many of them have failed or are now in difficulties. Owing to remote situation, difficulties of transport, and bad management, many rich in ore are not paying, and the only ones now making large profits are those of Huanchaca and Colquechaca. The Oruro mines are prospering, and an amalgamation of the different mines is expected shortly to materially improve their prospects. The silver occurs partly in strong veins of pyrites and partly in veins of its own. The rock-formations are mostly of porphyry or slate. Besides the silver ores proper, are worked tinstone and antimony glance, the latter only for the sake of its silver. Rich pockets of pure silver are also found, especially in the slate.

As markets for their products the mines depend chiefly on the works in the neighbourhood, as ores containing less than 6 per cent. of silver will not repay the cost of exportation.

The method of working is wasteful, but is controlled by local circumstances. Drifts with about 3 per cent. rise lead up to points suitable for the sinking of shafts, from which at vertical intervals of from 10 fathoms to 30 fathoms passages lead to the veins, these being generally worked in step fashion. The firm nature of the surrounding rock renders very little walling or propping necessary, only some dry stone arching being used at the entrances to main drifts. The shafts are about 160 fathoms deep,

and owing to scarcity of fuel are worked by horse gins. Surveying is carried on in very primitive fashion and is not controlled by Government, and in consequence, if a rich vein be struck, its owner has to endure considerable litigation with his neighbours.

The ores brought to the day contain about 1 per cent. of silver. They are crushed and sorted, in which work women and children are employed, and in some cases the ores are washed. For exportation they are ground into fine meal; but those for the local works are brought down to the size of nuts. The working is very wasteful and much ore is stolen. Most mines have their own silver works situated at distances of five or six miles off, where water power is obtainable, to which the ores are brought by carts or llamas. The silver works employ the process of amalgamation exclusively, and work in an extremely costly manner. The cost ranges from £6 10s. to £9 per ton and the loss of silver in the process amounts to about 30 per cent. The ores are ground in machines driven by water power; then, collected in boxes and mixed with salt, they are roasted in a furnace and finally amalgamated in copper vats. Only one company possesses an amalgamation mill, the rest resorting to stirring by hand with rods. The amalgam is washed with water, filtered in cotton bags, and then melted. The loss of quicksilver is from 4 oz. to 6 oz. per lb. The cylindrical bars of silver obtained have a weight of about 1 cwt. each.

About 2,000 persons are employed in the mines. A shift lasts about twelve hours, the time actually worked being about eight hours, and the wage of a hewer is about 2s. 10d. per day. The miners are chiefly Indians.

A. R. L.

MINING SCHOOLS.

American Mining Schools. By Professor R. H. Richards. *Transactions of American Institute of Mining Engineers, Vol. XV., pp.* 309–340, 809–818.

Mining Schools.	Age of Admission.	Length of Course.	Graduates in Mining.	Mining Students now in College.	Weeks of Actual Lecturing.
American—	Years.	Years.			Per Year.
Columbia College	18	4	346	87	32
Lafayette University	—	4	33	12	37
Lehigh University	16	4	25	68	36
Massachusetts Institute of Technology	17	4	88	30	30
University of—					
California	16	4	31	23	34
Illinois	15	4	5	3	36
Michigan	16	4	(?)	8	36
Pennsylvania	—	5	(?)	17	30
Wisconsin	15	4	15	3	38
Washington University	16	4	28	7	40
Foreign—					
Aachen K. Tech. Hochschule ...	19	3 or 4	18[1]	43	38
Clausthal K. Bergakademie ...	19	3 or 4	100[2]	100	37
Freiberg „	18	3	200[3]	163	36
Liege	18	5	678[4]	—	36
Stockholm K. Tek. Högskolan ...	19	4	500[5]	17	32

(1) Since 1874. (2) Since 1860. (3) Since 1872. (4) Since 1836. (5) Since 1821.

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